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CLAIMS

[Claim 1] Stage equipment which is characterized by providing the following and with which the movable object was laid on the base. Two or more three or more periodic-damping meanses to attenuate vibration between the aforementioned installation side and the aforementioned base while supporting the aforementioned base on the installation side of the aforementioned stage equipment, respectively. A damping-property adjustable means to change either [at least] the spring constant of one predetermined piece or two or more predetermined periodic-damping meanses in two or more aforementioned periodic-damping meanses, or a damping coefficient according to the move state of the aforementioned good dynamic body.
[Claim 2] Stage equipment for aligners which has the substrate stage which is characterized by providing the following, and which moves a sensitization substrate two-dimensional, and the base in which this substrate stage is laid, and exposes a mask pattern on the aforementioned sensitization substrate. Two or more three or more periodic-damping meanses to attenuate vibration between the aforementioned installation side and the aforementioned base while supporting the aforementioned base on the installation side of the aforementioned stage equipment, respectively. A damping-property adjustable means to change either [at least] the spring constant of one predetermined piece or two or more predetermined periodic-damping meanses in two or more aforementioned periodic-damping meanses, or a dumping coefficient according to the move state of the aforementioned substrate stage.
[Claim 3] It is stage equipment according to claim 1 or 2 which one aforementioned predetermined piece or two or more aforementioned predetermined periodic-damping meanses have the movable object arranged in predetermined viscous fluid, respectively, and is characterized by for the aforementioned damping-property adjustable means changing the viscous-drag coefficient of the aforementioned viscous fluid, and changing a dumping coefficient.
[Claim 4] The aforementioned damping-property adjustable means is stage equipment according to claim 1 or 2 characterized by changing a spring constant by inserting [member / spring] between the aforementioned installation side and the aforementioned base to the aforementioned periodic-damping means and parallel which are set as the adjustable object of a damping property.

[Claim 5] One aforementioned predetermined piece or two or more aforementioned predetermined periodic-damping meanses are stage equipment according to claim 1 or 2 characterized by changing a spring constant [in / the aforementioned electric actuator / it has the electric actuator which gives the energization force over the aforementioned base from the aforementioned installation side, and / in the aforementioned damping-property adjustable means], respectively.

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention is applied to the stage equipment of the aligner which bakes and exposes the pattern on a mask to sensitization substrates, such as a wafer with which especially sensitive material was applied, about the stage equipment which has the inhibition mechanism of a shake or vibration, and is suitable.
[0002]
[Description of the Prior Art] In the aligner used for the integrated circuit of the former, for example, a semiconductor, or manufacture of a liquid crystal display element, it being necessary to imprint with high precision, and suppressing the shake and vibration by the mask or the substrate as much as possible on the substrates (a wafer, glass plate, etc.) by which the pattern on masks (reticle etc.) was applied to the photoresist is called for.
[0003] Therefore, composition by which the whole equipment is carried on a vibrationproofing base a deflection and for the purpose of reduction of transfer of vibration with this kind of equipment from before is taken. The example is explained with reference to drawing 10 . Drawing 10 shows the outline block diagram of an example of the conventional aligner, and sets it to this drawing 10 . The reticle stage 2 which lays the wafer stage WS in which the wafer 4 was laid, a projection optical system 3, and a reticle 1, the lighting optical system EL And the aligner main part 11 which consists of surface plate 9 grade which supports the columns 22 and 23 which support those members, and columns 22 and 23 is supported by three pieces or four vibrationproofing mountings which have been arranged at the pars basilaris ossis occipitalis of the aligner main part 11. In drawing 10 , only two vibrationproofing mountings 52a and 52b are shown among those. In addition, the control rack 28 with which the control system which controls the handler which is not illustrated [which performs receipt and supply of the lighting optical system EL, a reticle stage 2, the wafer stage WS and a wafer 4, or a reticle 1] was contained is arranged in somewhere else [the aligner main part 11].
[0004] The vibrationproofing mountings 52a and 52b are being fixed so that a mutual position may not shift on a base plate 13. These vibrationproofing mountings 52a and 52b are usually constituted by the combination of a spring material and periodic-damping material. A vibrationproofing system as shown in this drawing 10 can be called vibrationproofing system passive so to speak into which vibration-proof ability is not changed according to a vibrational state or the states (posture etc.) of equipment. Generally such vibrationproofing bases are called "passive vibrationproofing base."
[0005] Drawing 11 is the outline block diagram showing another example of the conventional aligner, and the aligner main part 11 is supported by two or more vibrationproofing mountings like the above-mentioned example in this drawing 11 . Drawing 11 shows two vibrationproofing mountings 61a and 61b among those. The vibrationproofing mountings 61a and 61b of the aligner of drawing 11 use an air

spring (air damper). It has the positive pressure source of supply 62 of 3 - 10 kgf/cm2 (gage pressure) in the exterior of an aligner, and the air spring is constituted by sending in air through pneumatic piping 65a and 65b, respectively in the air chamber sealed by the rubber prepared in the vibrationproofing mountings 61a and 61b.

[0006] In addition, flow control valves 63a and 63b are formed just before the inlet of the air of the vibrationproofing mountings 61a and 61b, respectively. These flow control valves 63a and 63b are interlocked with the level sensors 64a and 64b which are interval measurement machines, such as a mechanical cable type which detects the posture of the aligner main part 11, or an electric type, respectively, and operate. Namely, by change of the posture of the aligner main part 11, the flow rate of the air supplied to each vibrationproofing mountings 61a and 61b can be changed, and the posture of the aligner main part 11 can be uniformly held now as a result. Other parts are the same as drawing 10 . The vibrationproofing mountings 61a and 61b of this example as well as the example of drawing 10 are called "passive vibrationproofing base."

[0007] On the other hand, sensors, such as an accelerometer or a displacement gage, detect the vibrational state of the exterior or the interior on real time, and the "active vibrationproofing base" which fluctuates the performance of vibrationproofing mounting positively is used increasingly recently.

[0008]

[Problem(s) to be Solved by the Invention] However, the need of controlling a shake and vibration still more precisely especially at the latest aligner is imminent, and the vibrationproofing base which is satisfied [with the above-mentioned conventional technology] of a performance side and a price side is not obtained. That is, in addition to the shake and vibration from the exterior, especially a floor line, in an aligner, you have to take into consideration the shake and vibration accompanying operation of the stage which moves exposed members, such as a wafer, or masks (reticle etc.) at high speed. At the time of acceleration of this stage, and a slowdown, big reaction force is applied to an aligner from the relation of operation reaction. This reaction force serves as an oscillating generation source of the main part of equipment on a vibrationproofing base. Physically, without changing an equipment configuration a lot, it is quite difficult to make this generating vibration into zero, and comes back to what "a periodic-damping performance is enlarged as much as possible, and vibration is attenuated for as quickly as possible" as a coping-with method.

[0009] When the above is arranged, it will be called two points of quick attenuation ** of vibration generated as a required function of a vibrationproofing base required for an aligner inside reduction and (b) equipment of the oscillating transfer from a (b) floor line. However, coexistence is a difficult function when these two points are considered from the requirement side of a vibrationproofing base. namely, as weak as much as possible as the ground or a floor line, in order to attain reduction of the oscillating transfer from a (b) floor line -- it connects, and it is necessary to prepare rigid weak "soft vibrationproofing base" for example, and, in other words, an air spring formula vibrationproofing base is equivalent to this On the other hand, in order to attain quick attenuation of vibration generated inside (b) equipment, it is necessary to realize strong rigid "hard vibrationproofing base" where an aligner main part can vibrate united with the ground or a floor line. In order to satisfy the latter performance, a vibrationproofing base which made the rigid big mechanical spring the component, or a thing like a rubber vibration insulator will be applied.

[0010] although the above-mentioned passive vibrationproofing base by the Prior art for example, has the advantage from which a thing appropriate at a comparatively cheap price is obtained by present also by the case of the vibrationproofing base which it is a low price, and did not reach for saying in simple rubber vibration insulator use, but used the air spring, it is difficult for fully satisfying the vibrationproofing function made required for the aligner described above Moreover, a sensor is installed within and without equipment and another active vibrationproofing base can build a vibrationproofing system with which it is made to satisfy both two functions that are the above-mentioned (b) and a (b), and is fully satisfied of various military requirements by oscillating control based on this detecting signal. However, while various sensors with sufficient precision are required, it is necessary to constitute an electronic circuitry quite complicated as a controller which controls vibrationproofing mounting. Therefore, the equipment of high cost is needed, and considering what can be applied to the highly efficient aligner demanded especially today, by present, it becomes high cost, so that profit cannot be taken.
[0011] this invention aims at offering the stage equipment of a low cost to which both two functions of quick attenuation ** of reduction of the oscillating transfer from a (b) floor line and vibration generated inside (b) equipment are satisfied in view of this point.
[0012]
[Means for Solving the Problem] In the stage equipment with which the movable object (6 7) was laid on the base (9), while the 1st stage equipment by this invention supports the base (9) on the installation side (13) of the stage equipment, respectively Two or more three or more periodic-damping meanses to attenuate vibration between the installation side (13) and its base (9) (12a, 12b), According to the move state of the movable object (6 7), a damping-property adjustable means (19) to change either [at least] the spring constant of one predetermined piece or two or more predetermined periodic-damping meanses in two or more of the periodic-damping meanses (12a, 12b) or a damping coefficient is established.
[0013] Moreover, the substrate stage to which the 2nd stage equipment by this invention moves a sensitization substrate (4) two-dimensional (6 7), In the stage equipment for aligners which has the base (9) in which this substrate stage (6 7) is laid, and exposes a mask pattern on the sensitization substrate (4) While supporting the base (9) on the installation side (13) of the stage equipment, respectively Two or more three or more periodic-damping meanses to attenuate vibration between the installation side (13) and its base (9) (12a, 12b), According to the move state of the substrate stage (6 7), a damping-property adjustable means (19) to change either [at least] the spring constant of one predetermined piece or two or more predetermined periodic-damping meanses in two or more of the periodic-damping meanses (12a, 12b) or a dumping coefficient is established.
[0014] In the 1st of this invention, and the 2nd stage equipment moreover, an example of the one predetermined piece or two or more predetermined periodic-damping meanses (12a, 12b) It has the movable object (42a, 42b) arranged in predetermined viscous fluid (45), respectively, and it is desirable for the damping-property adjustable means (19) to change the viscous-drag coefficient of the viscous fluid (45), and to change a dumping coefficient in this case.
[0015] Moreover, other examples of the damping-property adjustable means (19) change a spring constant by inserting [member / (25) / spring] between the installation side (13) and its base (8) in parallel with the periodic-damping means

(12a, 12b) set as the adjustable object of a damping property. Moreover, another example of a means to change the spring constant is a means to change the spring constant which the gain of a position feedback is changed, for example, a spring constant is changed indirectly, or is directly expressed with the energization force / change, when an electric actuator (31; 34) is used.

[0016]

[Function] According to the 1st stage equipment of this this invention, according to the move state of a movable object (6 7), the spring constant or dumping coefficient of a periodic-damping means (12a, 12b) can be changed by the damping-property adjustable means (19), and the periodic-damping property of stage equipment can be changed. When it seems that he does not want to follow, for example, to transmit the vibration from the stage equipment outside to stage equipment, a spring constant can be made small and it can respond. On the other hand, it can respond by making high rigidity of stage equipment, such as enlarging a dumping coefficient, to converge quickly the vibration inside equipment which is followed on movement of a movable object (6 7).

[0017] Moreover, according to the 2nd stage equipment of this invention, two functions of quick attenuation ** of vibration generated inside reduction and (b) equipment of the oscillating transfer from a (b) floor line required as stage equipment of an aligner can both be satisfied to cheap cost. As mentioned above, it does not need to be satisfied [with this time] of two functions required as stage equipment of an aligner. It is the time when the pattern of a mask (1) bakes on a sensitization substrate (4) at, and is exposed, the time of various kinds of optical alignment operation, etc. that the function which is (**) is needed for the maximum. Moreover, it is the acceleration time and the deceleration time of a substrate stage (6 7) in the time of stepping to which a substrate stage (6 7) is moved at high speed that the function of (**) becomes important.

[0018] If it is made a setup which changes the periodic-damping property of a periodic-damping means (12a, 12b) to two kinds for example, in stage equipment there and will think from the function of an aligner, it can consider as the stage equipment with which it is satisfied of both two functions, a (b) and a (b), as a result. namely, the exposure time -- only setting -- rigidity -- "-- soft -- " -- what is necessary is just to carry out If it carries out that it cooks of the rigidity in "" to the time in connection with the acceleration slowdown of other stages, **** (setting) of the vibration generated by acceleration slowdown can be carried out quickly enough.

[0019] By the way, although such time management is performed by the damping-property adjustable means (19), a sensor and a control section special for setting change of this periodic-damping means (12a, 12b) are not needed. Namely, what is necessary is to emit a control signal according to the operation situation of an aligner from a damping-property adjustable means (19), for example, just to control operation of viscous fluid (45). Therefore, according to the 2nd stage equipment of this invention, the function which is very cheap cost compared with the above-mentioned active vibrationproofing base, and an active vibrationproofing base has can be attained.

[0020] Furthermore, the drive of the stage equipment in an aligner and the combination of a halt are not necessarily applied only in exposure operation, and are applied also in operation of delivery with the handler at the time of exchange of various kinds of optical alignment operation, a mask (1), a sensitization substrate (4), etc. As for a control parameter called the drive speed and acceleration of a

substrate stage (6 7) according to each case, differing is common. therefore, the "rigidity" which should be set as a periodic-damping means (12a, 12b) -- "-- soft/-- it is hard -- it is desirable several step story and that change of the set point of 4 - 5 stage can be performed not only according to two stages of " but according to each case if it may be able to do According to the 2nd stage equipment of this invention, two or more of these set points can be easily set up by the damping-property adjustable means (19).

[0021]

[Example] Hereafter, one example of the stage equipment by this invention is explained with reference to drawing 1 - drawing 3 , and drawing 8 . this example applies this invention to the projection aligner of the step-and-repeat method which reduces the pattern on a reticle by the projection optical system, and is exposed to each shot field on a wafer.

[0022] In this drawing 1 , the outline composition of the projection aligner of this example is shown, the lighting light IL for exposure injected from the lighting optical system EL is irradiated by the lighting field on a reticle 1, the circuit pattern drawn in the lighting field is reduced through a projection optical system 3, and drawing 1 is imprinted by the front face of a wafer 4. As a lighting light IL, laser beams, such as others and KrF excimer laser light, ArF excimer laser light, etc., are used. [bright lines / (i line with a wavelength of 365nm, g line with a wavelength of 436nm, etc.) /, such as a mercury lamp,] Here, in drawing 1 , the Z-axis is taken in parallel with the optical axis AX of a projection optical system 3, and the X-axis is taken in the space of drawing 1 within a flat surface perpendicular to the optical axis AX at right angles to the space of a Y-axis and drawing 1 in parallel.

[0023] In drawing 1 , vacuum adsorption of the reticle 1 on which the circuit pattern was drawn is carried out on a reticle stage 2, and this reticle stage 2 positions a reticle 1 to the direction of X, the direction of Y, and a hand of cut (the direction of theta) within a two-dimensional flat surface (XY flat surface) perpendicular to the optical axis AX of a projection optical system 3. The position coordinate in the two-dimensional flat surface of a reticle stage 2 is always detected with the resolution of about 0.01 micrometers by the laser interferometer arranged on the outskirts of a move mirror and the outskirts on the non-illustrated reticle stage 2.

[0024] As shown in drawing 1 , a wafer 4 is held by vacuum adsorption on a non-illustrated wafer electrode holder, and the wafer electrode holder is being fixed on Z stage 5. Moreover, Z stage 5 is laid on the X stage 6 where only the length for a diameter of the greatest wafer exposed by this projection aligner can move in the direction of X, and the X stage 6 is laid on the Y stage 7 where only the length for a diameter of the greatest wafer can move in the direction of Y. A wafer stage consists of these Z stages 5, an X stage 6, a Y stage 7, and wafer base 8 grade.

[0025] It drives by the motor 15 through a feed screw 14, and moves in the direction of Y relatively to the wafer base 8, and the Y stage 7 is driven by the motor 16 through a non-illustrated feed screw, and moves in the direction of X relatively to the Y stage 7 on the X stage 6. Moreover, by the non-illustrated mechanical component, to the image formation side of a projection optical system 3, Z stage 5 can incline in the arbitrary direction, and can be moved slightly in the optical-axis AX direction (Z direction). Moreover, surrounding rotation of an optical axis AX is also possible for Z stage 5.

[0026] Furthermore, the firm measurement of the X coordinate and Y coordinate of Z stage 5 is carried out by the move mirror fixed on Z stage 5, and the laser interferometer of the non-illustrated exterior. Furthermore, the focal position

detection system of the oblique incidence method which consists of irradiation optical system which projects images, such as a pinhole or a slit pattern, aslant to an optical axis AX towards the exposure side of the wafer 4 near the image formation side of a projection optical system 3 although not illustrated, and light-receiving optical system which carries out re-image formation of the image from the projected reflected light bunch from an image is prepared. The position of the Z direction of the front face of a wafer 4 is detected by this focal position detection system, and auto-focusing is performed so that the front face of a wafer 4 may agree in the image formation side of a projection optical system 3 based on the detection information.

[0027] The aligner main part 11 which consists of surface plate 9 grades which support Z stage 5, the X stage 6, the Y stage 7 and the wafer stage that consists of wafer base 8 grades, the lighting optical system EL, a projection optical system 3, a reticle stage 2, the columns 22 and 23 that support those devices, and columns 22 and 23 as mentioned above is installed after four vibrationproofing mountings. Drawing 1 shows only two vibrationproofing mountings 12a and 12b. The vibrationproofing mountings 12a and 12b are being fixed so that a mutual position may not shift on a base plate 13. About the vibrationproofing mountings 12a and 12b, it mentions later in detail. In addition, the aligner main part 11 is equipped also with the alignment system which is not illustrated for in addition to this performing alignment of a reticle 1 and a wafer 4.

[0028] Moreover, the control system 19 (refer to drawing 2) contained in the control rack 28 of the equipment exterior also controls operation of the vibrationproofing mountings 12a and 12b while controlling the handler which is not illustrated [which performs receipt and supply of the lighting optical system EL, a reticle stage 2, a wafer stage and a wafer 4, or a reticle 1]. Next, vibrationproofing mounting 12a is explained with reference to drawing 2 . The same is said of vibrationproofing mounting 12b and other vibrationproofing mountings. In addition, the structure from which the oscillating absorbent system according [vibrationproofing mounting 12a] to a spring member and the oscillating absorbent system by viscous fluid constitute the oscillating absorbent system according the structure which constitutes the oscillating absorbent system by the spring member on account of following explanation to a spring buffer system and viscous fluid by becoming integral construction is explained as a fluid buffer system. Vibrationproofing mounting 12a of this example is the structure which consists of a spring buffer system and a fluid buffer system.

[0029] the cross section in which drawing 2 shows the internal configuration of vibrationproofing mounting 12a of this example -- it is -- this drawing 2 -- setting -- a crowning -- a member 43 is a portion connected to the aligner main part 11 of drawing 1 , and the undersurface side of a case 44 is being fixed to the base plate 13 of drawing 1 the spring which constitutes the spring buffer system of this example in the center section of the lid 48 of a case 44 -- the end of a member 20 is fixed -- having -- a spring -- the other end of a member 20 -- a crowning -- it is fixed to the member 43 moreover, a crowning -- two or more wing-like members (drawing 2 shows only two-piece 42a of them, and 42b) which constitute the fluid buffer system of this example in a member 43 -- a spring -- as a member 20 is surrounded, it is attached -- having -- **** -- a crowning -- each pedicel 49a and 49b of the wing-like members 42a and 42b fixed to the member 43 is ****(ed) to opening of a lid 48

[0030] The viscous fluid 45 which constitutes the principal part of the fluid buffer

system of this example is filled up into container 50a of the shape of a thick cylinder within a case 44 with the state where leak and there is nothing, and the wing portion of the wing-like members 42a and 42b is dipped into viscous fluid 45. Moreover, the electrode 46 of a couple was formed in the front face of a case 44, and these electrodes 46 have flowed with viscous fluid 45. if the voltage impressed between the electrodes 46 of a couple is changed from the power supply which the viscous fluid 45 used here is an ER (Electro Reological) fluid from which viscosity changes corresponding to the change of potential as mentioned later, and was prepared outside -- the viscosity of viscous fluid 45 -- changing -- consequent -- attenuation of vibrationproofing mounting 12a -- a law -- a property changes The viscosity of this viscous fluid is controlled by the control system 19 prepared in the exterior of vibrationproofing mounting 12a.

[0031] Next, the viscous fluid 45 which constitutes the fluid buffer system of this example is explained. Viscous fluid 45 is as above-mentioned electrorheological fluid from which the viscosity changes corresponding to the change of potential impressed to viscous fluid. In the state as it is, although this electrorheological fluid is the colloidal solution with a fluidity, if severalkV [/mm] electric field are applied, it will lose a fluidity in proportion to field strength, and will change to the state near a solid-state depending on the kind of electrorheological fluid. Furthermore, the speed of response of the viscous change in electrorheological fluid is about 0.1 secs, for example, has the speed of response easily applicable to the projection aligner of stepper type and step - and - scanning method.

[0032] As this electrorheological fluid, the distributed type thing which distributed the particle of electric polarization nature, and the liquid crystal type thing which used liquid crystal recently are in the fluid of insulation, such as a silicone oil. Although distributed type electrorheological fluid is cheap in price, there is a fault which the distributed particle separates out of a solution. a field where a particle does not separate liquid crystal type electrorheological fluid, in addition the ER effect is extinguished with distributed type electrorheological fluid to it and where a shear rate is high -- even when -- although there is an advantage -- the ER effect is not lost -- there is a difficulty that it is high in price Various kinds of fluids are already marketed as the above electrorheological fluid from each maker, such as Asahi Chemical Industry, Nippon Oil, NIPPON SHOKUBAI, Japanese MEKUTORON, Dow Corning, and Toray Industries.

[0033] As viscous fluid 45, change of coefficient of viscosity is [from / especially] large among the above electrorheological fluid, it is rapid response, power consumption is small, it excels in the dispersibility of a particle, and operation temperature chooses a product cheap in price widely. Next, it explains per operation of the stage equipment of this example. the oscillation characteristic of vibrationproofing mounting 12a which drawing 3 shows the ** type view for explaining the oscillating model of vibrationproofing mounting 12a used by this example, is arranged in this drawing 3 between the aligner main part 11 and the base plate 13 which is the installation side of an aligner, and supports the aligner main part 11 -- the spring of drawing 2 -- spring constant [of a member 20] K, and periodic damping -- the dumping coefficient C based on the viscous-drag coefficient of the viscous fluid 45 which is a member is determined

[0034] this example -- a spring -- spring constant K of a member 20 is fixed Therefore, the oscillation characteristic of vibrationproofing mounting 12a is changed by changing the dumping coefficient C based on the viscous-drag coefficient of viscous fluid 45 **. In this example, electrorheological fluid is used as

viscous fluid 45. By controlling the applied voltage to viscous fluid now, the electrorheological fluid which can change the coefficient of viscosity of viscous fluid 45 by the ratio of 10 times or more is available, and can control the height of the peak of the resonance scale factor in the resonant frequency in a low frequency region, and the transmissibility of vibration in an inside RF region by applying such electrorheological fluid.

[0035] As mentioned above, it does not need to be satisfied [with this time] of two functions of quick attenuation ** of vibration generated inside reduction and (b) equipment of the oscillating transfer from a (b) floor line required as a vibrationproofing base of an aligner. It is the time when the pattern of a reticle 1 bakes on a wafer 4 at, and is exposed, the time of various kinds of optical alignment operation, etc. that the function of a (b) is needed for the maximum. Moreover, it is the acceleration-and-deceleration time of the reticle stage 2 at the time of moving a wafer stage and a reticle stage 2 at high speed, and a wafer stage that the function of a (b) becomes important.

[0036] Drawing 8 shows the graph for explaining the drive of the wafer stage in the stepper type projection aligner of this example, and the timing of exposure, Time t is shown in the horizontal axis and the speed VW of a wafer stage is shown in the vertical axis. First, a wafer stage accelerates in a period 71, uniform operation is performed between periods 72, and a wafer stage is slowed down in a period 73. The period 75 when the very small range is positioned in the period 74 just behind it in, and it is stood still after the end is the exposure time. The total time 76 is the sum of the above periods 71-75, and a drive and exposure of a wafer stage are repeated this period. Moreover, the speed VW on a vertical axis shows the highest drive speed of a wafer stage.

[0037] If it is made a setup which changes the periodic-damping property of the vibrationproofing mountings 12a and 12b to two kinds in the stage equipment of this example there and will think from the function of an aligner, it can consider as the vibrationproofing base with which it is satisfied of both two functions, a (b) and a (b), as a result. namely, the period 75 which is the exposure time -- only setting -- rigidity -- "-- soft -- " -- it carries out Namely, what is necessary is just to make viscosity of viscous fluid 45 small. Thereby, the oscillating transfer from the equipment outside is intercepted mostly. If it carries out that it cooks of the rigidity in "" to the time in connection with the acceleration slowdown of other stages, vibration generated by acceleration slowdown can be ****(ed) quickly enough.

[0038] By the way, although such time management is performed by the control system 19 of drawing 2 which controls the whole aligner, a sensor special for property change of the vibrationproofing mountings 12a and 12b of this example is not needed. Namely, what is necessary is to emit a control signal according to the operation situation of an aligner from a control system 19, and just to control the applied voltage to viscous fluid 45. Therefore, according to the stage equipment of this example, the function which is very cheap cost compared with an active vibrationproofing base, and an active vibrationproofing base has can be attained.

[0039] Furthermore, the drive of stages, such as the reticle stage 2 in an aligner and a wafer stage, and the combination of a halt are not necessarily applied only in exposure operation, and are applied also in operation of delivery with the handler at the time of exchange of various kinds of optical alignment operation, a wafer 4, and reticle 1 grade etc. As for a control parameter called the drive speed and acceleration of a stage according to each case, differing is common. therefore, the "rigidity" which should be set as the vibrationproofing mountings 12a and 12b -- "--

soft/-- it is hard -- it is desirable several step story and that change of the set point of 4 - 5 stage can be performed not only according to two stages of " but according to each case if it may be able to do By the method to which the viscosity of the viscous fluid 45 of this example is changed, since the rigidity can be continuously changed by predetermined within the limits, two or more of these set points can be easily set up by the control system 19.

[0040] Next, other examples of the stage equipment by this invention are explained with reference to drawing 4 . Drawing 4 shows the ** type view for explaining the oscillating model of vibrationproofing mounting 21a of this example. vibrationproofing mounting 12a [in / the example of drawing 1 / in this example] -- replacing with -- dumping coefficient C 1 the spring which it is fixed and is a thing using vibrationproofing mounting 21a to which a spring constant can be changed, and was united with the fluid buffer system by viscous fluid 45A as shown in drawing 4 -- a member -- 20A -- adding -- the near -- a piece or two or more springs -- it has prepared free / insertion and detachment of a member 25 in this case, a spring -- even if it unites with the fluid buffer system by viscous fluid 45A and a member 25 is not, whichever is sufficient as it In addition, also in the stage equipment of this example, four vibrationproofing mountings are prepared like drawing 1 .

[0041] drawing 4 -- setting -- a piece or two or more springs -- although the end of a member 25 is being fixed to the base plate 13, the other end does not always contact in the aligner main part 11, but control which connects and releases the field 26 where the other end and aligner main part 11 face with a driving gear 27 is performed As a driving gear 27 which performs this connection and release operation, various drive systems, such as machine operation by use of electromagnetic force, a vacuum adsorption power, and pneumatic pressure, the motor, etc., can be used. Connection of a driving gear 27 and control of release are performed by the control system 19. Other composition is the same as the stage equipment of drawing 1 .

[0042] The oscillating model of drawing 4 explains operation of vibrationproofing mounting of this example briefly. in addition, the case where two or more spring members are prepared in vibrationproofing mounting 21a -- those springs -- although the spring constants of a member differ, respectively -- spring constant K2 It represents and explains. namely, a spring -- the number of change by the combination of the number of members 25 -- spring constant K2 It shall change. In addition, operation of viscous fluid 45A is not controlled by the control system 19, but most viscous-drag coefficients of viscous fluid 45A are governed by only environmental temperature. Therefore, at ordinary temperature, it is the damping coefficient C 1. It thinks as fixed.

[0043] the damping property by viscous fluid 45A in which vibrationproofing mounting 21a has a damping property -- adding -- a spring -- a member -- spring constant K1 of 20A a spring -- spring constant K2 of a member 25 Spring constant KT by combination By making it change, further many oscillation characteristic values can be set up as compared with the example of drawing 1 . a spring -- if the number of members 25 is set to n -- spring constant K2 several [of change] -- combination about which P takes i pieces from n pieces nCi ** -- it carries out and is set to (1+nC1+nC2+--+nCn) at the maximum

[0044] for example, a spring -- if the number of members 25 is three -- spring constant K2 The number of change is set to 8 at the maximum. spring constant KT although change is not continuous -- the spring of the predetermined number --

forming a member 25 -- spring constant KT of the form almost near continuation It can also obtain. therefore, a spring -- member 20A and two or more springs -- it can respond to the demand of various oscillation characteristics to stage equipment with the combination of a member 25 and viscous fluid 45A

[0045] in addition -- this example -- vibrationproofing mounting 21a -- a spring -- although constituted by the combination of the spring buffer system by members 20A and 25, and the fluid buffer system by viscous fluid 45A, there may not be a fluid buffer system However, it is more more effective to apply combining both spring buffer system and fluid buffer system. Next, another example of the stage equipment by this invention is explained with reference to drawing 5 . that to which this example changes the spring constant of vibrationproofing mounting like the example of drawing 4 -- it is -- a spring constant -- K3 a spring -- a member -- the spring buffer system and the damping coefficient C 2 by 20B The vibrationproofing mounting 30 of the assistance which used the actuator 31 of a voice coil motor (henceforth "VCM") method near the vibrationproofing mounting 28a which consists of fluid buffer systems by viscous fluid 45B is formed. In addition, also in the stage equipment of this example, four vibrationproofing mountings are prepared like the example of drawing 1 .

[0046] The vibrationproofing mounting 30 of the assistance by which the lower part was fixed to the base plate 13 near the vibrationproofing mounting 28a as drawing 5 showed the ** type view for explaining the oscillating model of vibrationproofing mounting of this example and it was shown in drawing 5 is installed. The VCM actuator 31 which constitutes the vibrationproofing mounting 30 consists of magnet section 31b fixed to coil section 31a and vibrationproofing mounting 30a which were fixed to the aligner main part 11, and the energization force over the aligner main part 11 changes from a base plate 13 according to the current passed to coil section 31a.

[0047] The position of the aligner main part 11 is faced and established in the pars basilaris ossis occipitalis of the aligner main part 11, and it is measured by position-sensor 33A which detects the position (height) of buckling-of-track section 11a of the pars basilaris ossis occipitalis of the aligner main part 11. Position-sensor 33A is being fixed to the base plate 13 through support frame 38A, and the physical relationship of position-sensor 33A and a base plate 13 is fixed. The measurement value of position-sensor 33A is supplied to position gain circuit 39A, and the VCM actuator 31 of the auxiliary vibrationproofing mounting 30 is controlled by position gain circuit 39A to generate the energization force in predetermined gain in the direction which sets the amount of gaps of the measurement value of position-sensor 33A to 0. And in this example, when a control system 19 changes the gain of the position in position gain circuit 39A, the spring constant of the VCM actuator 31 is changed indirectly. Moreover, although various length measurement sensors can be used as position-sensor 33A, use of a laser reflection type sensor, an eddy current sensor, etc. is desirable from a cost-side. Other composition is the same as that of the stage equipment of drawing 1 .

[0048] Next, still more nearly another example of the stage equipment by this invention is explained with reference to drawing 6 . This example is what used the actuator of a feed screw method by motorised as vibrationproofing mounting, and has not prepared vibrationproofing mounting which consists of a spring buffer system like the above-mentioned example, and a fluid buffer system in this example. In addition, also in the stage equipment of this example, four vibrationproofing mountings are prepared like drawing 1 .

[0049] Drawing 6 shows the ** type view for explaining the oscillating model of vibrationproofing mounting of this example, and vibrationproofing mounting 32a by which the lower part was fixed to the base plate 13 is installed in this drawing 6 . The actuator 34 of the electric type which constitutes the drive of vibrationproofing mounting 32a consists of drive-motor 34b turning around thread-part 34a screwed in the nut section of spindle 34c which runs against field 26A which the aligner main part 11 counters, and this spindle 34c, and this thread-part 34a etc. It is fixed to a base plate 13 and the pars basilaris ossis occipitalis of vibrationproofing mounting 32a has composition which absorbs the vibration from the aligner main part 11.

[0050] The position of the aligner main part 11 is measured like the stage equipment of drawing 5 by position-sensor 33A which detects the position of buckling-of-track section 11a of the pars basilaris ossis occipitalis of the aligner main part 11. The measurement value of position-sensor 33A is supplied to position gain circuit 39B, and position gain circuit 39B controls the energization force over the aligner main part 11 of an actuator 34 by position gain to set the amount of gaps of the measurement value of position-sensor 33A to 0. Also by this example, a control system 19 adjusts the position gain in the position gain circuit 39B, and changes the spring constant in an actuator 34. Other composition is the same as the stage equipment of drawing 1 .

[0051] Unlike the VCM actuator 31 of drawing 5 , the actuator 34 which consists of the feed screw and drive motor of this example is independently applicable also to the big equipment of a load. However, you may use together with vibrationproofing mounting which consists of other spring buffer systems or fluid buffer systems. Next, the modification of the stage equipment of drawing 5 is explained with reference to drawing 7 . This example allots a load cell between the vibrationproofing mountings 30 and the aligner main parts 11 of assistance of drawing 5 .

[0052] Drawing 7 shows the ** type view for explaining the oscillating model of vibrationproofing mounting of this example, and the load cell 35 is arranged in drawing 7 between the base of the aligner main part 11, and the upper surface of the outer case of the vibrationproofing mounting 30 which has the VCM actuator 31. The measured value of the load from a load cell 35 is supplied to drive circuit 39C, and the measurement result of the position from position-sensor 33A is also supplied to drive circuit 39C. Drive circuit 39C controls the energization force of the VCM actuator 31 to make into a predetermined value the spring constant which is the load detected by the load cell 35, i.e., the value which **(ed) the force in the amount of gaps (variation rate) detected by displacement-sensor 33A. Moreover, a control system 19 makes the value of the spring constant in the drive circuit 39C change if needed. Other composition is the same as that of the stage equipment of drawing 5 .

[0053] The oscillating model of drawing 7 explains operation of vibrationproofing mounting of this example briefly. the damping property by viscous fluid 45B in which vibrationproofing mounting of this example has a damping property -- adding -- a spring -- a member -- spring constant K3 of 20B the spring of the VCM actuator 31 which constitutes the auxiliary vibrationproofing mounting 30 -- constant -- several kA Spring constant KT by combination Various damping properties can be set up by making it change.

[0054] If the force concerning a load cell 35 is made into applied force F and the amount of gaps of the position of the aligner main part 11 measured by position-

sensor 33A is made into a variation rate delta x, the value (F/delta x) which **(ed) applied force F by delta x is equivalent to the usual spring constant, when the VCM actuator 31 is regarded as a spring material. therefore, a spring -- constant -- several kA (F/delta x) -- it is -- a spring -- constant -- several kA What is necessary is just to change the applied force F to the same variation rate delta x into changing. therefore, the thing for which the current passed to coil 31a by the control system 19 is controlled -- the spring of the VCM actuator 31 -- constant -- several kA It is changeable.
[0055] It is the spring constant KT of the whole stage equipment only by controlling the VCM actuator 31 by drive circuit 39C electrically, since the vibrationproofing mounting 30 of assistance by the VCM actuator 31 is formed according to the method of this example. It can be made to be able to change broadly and can respond to the demand of various oscillation characteristics to stage equipment. According to the stage equipment by the above example, vibrationproofing mounting which consists of a spring buffer system and a fluid buffer system can be installed between the base plates 13 used as the aligner main part 11 and the installation side of an aligner, vibration from which various [, such as vibration accompanying movement of the reticle stage 2 of an aligner or a wafer stage and vibration from the installation side of an aligner,] differ can be buffered, and the performance of an aligner can be raised.
[0056] In addition, you may use an air spring as a spring member in an above-mentioned example. Moreover, the buffer system which used air, such as for example, a pneumatics cylinder, as a fluid buffer system can also be used. In addition, although the above-mentioned example applies the stage equipment of this invention to a stepper type projection aligner, it is also applicable to the aligner of step - which synchronizes and scans a reticle and a wafer, and - scanning method.
[0057] Drawing 9 shows the graph for explaining the drive of the wafer stage of the aligner of step - and - scanning method, and the timing of exposure, Time t is shown in the horizontal axis and the speed VW of a wafer stage is shown in the vertical axis. As shown in drawing 9 , in a period 77, a wafer stage accelerates, and performs convergence to a predetermined scan speed in the period 78 just behind it, and exposure is performed in the period 79 when a scan speed becomes fixed. The wafer stage between periods 79 is a scan speed VW2. It moves. After exposure is completed, a wafer stage is slowed down in a period 80. In the period 81 just behind it, positioning to the scanning starting position of the following exposure shot is performed. The total time 82 is the sum of the above periods 77-81, and a drive and exposure of a wafer stage are repeated this period.
[0058] the period 79 which is the exposure time like stepper type stage equipment -- only setting -- rigidity -- "-- soft -- " -- what is necessary is just to carry out If it carries out that it cooks of the rigidity in "" to the time in connection with the acceleration slowdown of other stages, vibration generated by acceleration slowdown can be ****(ed) quickly enough. Moreover, in the above-mentioned example, although the helical compression spring is used as a spring member, you may use flat spring, a griddle, etc.
[0059] Thus, this invention is not limited to the above-mentioned example, but can take composition various in the range which does not deviate from the summary of this invention.
[0060]
[Effect of the Invention] According to the 1st stage equipment of this invention,

according to the move state of a movable object, the oscillation characteristic of a periodic-damping means can be changed by the damping-property adjustable means, and the periodic-damping property of stage equipment can be changed. When it seems that he does not want to follow, for example, to transmit the vibration from the stage equipment outside to stage equipment, the rigidity of a periodic-damping means is set up small, and on the other hand, it can respond by making rigidity of a periodic-damping means high to converge quickly the vibration inside equipment which is followed on movement of a movable object.
[0061] Moreover, according to the 2nd stage equipment of this invention, two functions of quick attenuation ** of vibration generated inside reduction and (b) equipment of the oscillating transfer from a (b) floor line required at an exposure time and the time of movement of a substrate stage as stage equipment of an aligner can both be satisfied to cheap cost. Furthermore, only in exposure operation, it is necessary to take the oscillation characteristic of a substrate stage into consideration also in operation of delivery with the handler at the time of exchange of various kinds of optical alignment operation, a mask, a sensitization substrate, etc. According to the 2nd stage equipment of this invention, two or more of these set points can be easily set up by the damping-property adjustable means.
[0062] In the 1st of this invention, and the 2nd stage equipment moreover, one predetermined piece or two or more predetermined periodic-damping meanses In having the movable object arranged in predetermined viscous fluid, respectively, and a damping-property adjustable means' changing the viscous-drag coefficient of viscous fluid and changing a damping coefficient For example, when ER (Electro Reological) fluid from which a viscous-drag coefficient changes with field strength as viscous fluid is used, The viscous-drag coefficient of viscous fluid can change from the power supply prepared outside only by controlling the voltage energized to viscous fluid by the damping-property adjustable means, a damping coefficient can change in connection with it, and the periodic-damping property of a periodic-damping means can be controlled according to the move state of a substrate stage as a result. Furthermore, a periodic-damping property can be continuously changed in the predetermined range.
[0063] Moreover, if it inserts [members / spring / two or more] between an installation side and the base in changing a spring constant by inserting / members / spring / a piece or / two or more] between an installation side and the base to the periodic-damping means and parallel from which a damping-property adjustable means is set as the adjustable object of a damping property, a periodic-damping property can be switched to two or more step story with very simple composition.
[0064] Moreover, when changing a spring constant with an electric actuator, it is simple in mechanism. furthermore, a perfect active vibrationproofing base -- like -- a variation rate -- complicated control is not performed according to detection values, such as a sensor, but since only the control which only changes the value of the gain, force / variation rate of a position feedback is sufficient, a control circuit has the advantage which is not complicated so much

TECHNICAL FIELD

[Industrial Application] this invention is applied to the stage equipment of the aligner which bakes and exposes the pattern on a mask to sensitization substrates, such as a wafer with which especially sensitive material was applied, about the

stage equipment which has the inhibition mechanism of a shake or vibration, and is suitable.

PRIOR ART

In the aligner used for the integrated circuit of the former, for example, a semiconductor, or manufacture of a liquid crystal display element, it being necessary to imprint with high precision, and suppressing the shake and vibration by the mask or the substrate as much as possible on the substrates (a wafer, glass plate, etc.) by which the pattern on masks (reticle etc.) was applied to the photoresist is called for.

[0003] Therefore, composition by which the whole equipment is carried on a vibrationproofing base a deflection and for the purpose of reduction of transfer of vibration with this kind of equipment from before is taken. The example is explained with reference to drawing 10 . Drawing 10 shows the outline block diagram of an example of the conventional aligner, and sets it to this drawing 10 . The reticle stage 2 which lays the wafer stage WS in which the wafer 4 was laid, a projection optical system 3, and a reticle 1, the lighting optical system EL And the aligner main part 11 which consists of surface plate 9 grade which supports the columns 22 and 23 which support those members, and columns 22 and 23 is supported by three pieces or four vibrationproofing mountings which have been arranged at the pars basilaris ossis occipitalis of the aligner main part 11. In drawing 10 , only two vibrationproofing mountings 52a and 52b are shown among those. In addition, the control rack 28 with which the control system which controls the handler which is not illustrated [which performs receipt and supply of the lighting optical system EL, a reticle stage 2, the wafer stage WS and a wafer 4, or a reticle 1] was contained is arranged in somewhere else [the aligner main part 11].

[0004] The vibrationproofing mountings 52a and 52b are being fixed so that a mutual position may not shift on a base plate 13. These vibrationproofing mountings 52a and 52b are usually constituted by the combination of a spring material and periodic-damping material. A vibrationproofing system as shown in this drawing 10 can be called vibrationproofing system passive so to speak into which vibration-proof ability is not changed according to a vibrational state or the states (posture etc.) of equipment. Generally such vibrationproofing bases are called "passive vibrationproofing base."

[0005] Drawing 11 is the outline block diagram showing another example of the conventional aligner, and the aligner main part 11 is supported by two or more vibrationproofing mountings like the above-mentioned example in this drawing 11 . Drawing 11 shows two vibrationproofing mountings 61a and 61b among those. The vibrationproofing mountings 61a and 61b of the aligner of drawing 11 use an air spring (air damper). It has the positive pressure source of supply 62 of 3 - 10 kgf/cm2 (gage pressure) in the exterior of an aligner, and the air spring is constituted by sending in air through pneumatic piping 65a and 65b, respectively in the air chamber sealed by the rubber prepared in the vibrationproofing mountings 61a and 61b.

[0006] In addition, flow control valves 63a and 63b are formed just before the inlet of the air of the vibrationproofing mountings 61a and 61b, respectively. These flow control valves 63a and 63b are interlocked with the level sensors 64a and 64b which are interval measurement machines, such as a mechanical cable type which detects the posture of the aligner main part 11, or an electric type, respectively,

and operate. Namely, by change of the posture of the aligner main part 11, the flow rate of the air supplied to each vibrationproofing mountings 61a and 61b can be changed, and the posture of the aligner main part 11 can be uniformly held now as a result. Other parts are the same as drawing 10 . The vibrationproofing mountings 61a and 61b of this example as well as the example of drawing 10 are called "passive vibrationproofing base."

[0007] On the other hand, sensors, such as an accelerometer or a displacement gage, detect the vibrational state of the exterior or the interior on real time, and the "active vibrationproofing base" which fluctuates the performance of vibrationproofing mounting positively is used increasingly recently.

EFFECT OF THE INVENTION

According to the 1st stage equipment of this invention, according to the move state of a movable object, the oscillation characteristic of a periodic-damping means can be changed by the damping-property adjustable means, and the periodic-damping property of stage equipment can be changed. When it seems that he does not want to follow, for example, to transmit the vibration from the stage equipment outside to stage equipment, the rigidity of a periodic-damping means is set up small, and on the other hand, it can respond by making rigidity of a periodic-damping means high to converge quickly the vibration inside equipment which is followed on movement of a movable object.

[0061] Moreover, according to the 2nd stage equipment of this invention, two functions of quick attenuation ** of vibration generated inside reduction and (b) equipment of the oscillating transfer from a (b) floor line required at an exposure time and the time of movement of a substrate stage as stage equipment of an aligner can both be satisfied to cheap cost. Furthermore, only in exposure operation, it is necessary to take the oscillation characteristic of a substrate stage into consideration also in operation of delivery with the handler at the time of exchange of various kinds of optical alignment operation, a mask, a sensitization substrate, etc. According to the 2nd stage equipment of this invention, two or more of these set points can be easily set up by the damping-property adjustable means.

[0062] Moreover, when it has the movable object with which one predetermined piece or two or more predetermined periodic-damping meanses have been arranged in predetermined viscous fluid, respectively in the 1st of this invention, and the 2nd stage equipment, a damping-property adjustable means changes the viscous-drag coefficient of viscous fluid and it changes a dumping coefficient, it is field strength as viscous fluid. When ER (Electro Reological) fluid from which a viscous-drag coefficient changes is used, the viscous-drag coefficient of viscous fluid can change from the power supply prepared outside only by controlling the voltage energized to viscous fluid by the damping-property adjustable means, a dumping coefficient can change in connection with it, and the periodic-damping property of a periodic-damping means can be controlled according to the move state of a substrate stage as a result. Furthermore, a periodic-damping property can be continuously changed in the predetermined range.

[0063] Moreover, if it inserts [members / spring / two or more] between an installation side and the base in changing a spring constant by inserting / members / spring / a piece or / two or more] between an installation side and the base to the periodic-damping means and parallel from which a damping-property adjustable means is set as the adjustable object of a damping property, a periodic-damping

property can be switched to two or more step story with very simple composition.
[0064] Moreover, when changing a spring constant with an electric actuator, it is simple in mechanism. furthermore, a perfect active vibrationproofing base -- like -- a variation rate -- complicated control is not performed according to detection values, such as a sensor, but since only the control which only changes the value of the gain, force / variation rate of a position feedback is sufficient, a control circuit has the advantage which is not complicated so much

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, the need of controlling a shake and vibration still more precisely especially at the latest aligner is imminent, and the vibrationproofing base which is satisfied [with the above-mentioned conventional technology] of a performance side and a price side is not obtained. That is, in addition to the shake and vibration from the exterior, especially a floor line, in an aligner, you have to take into consideration the shake and vibration accompanying operation of the stage which moves exposed members, such as a wafer, or masks (reticle etc.) at high speed. At the time of acceleration of this stage, and a slowdown, big reaction force is applied to an aligner from the relation of operation reaction. This reaction force serves as an oscillating generation source of the main part of equipment on a vibrationproofing base. Physically, without changing an equipment configuration a lot, it is quite difficult to make this generating vibration into zero, and comes back to what "a periodic-damping performance is enlarged as much as possible, and vibration is attenuated for as quickly as possible" as a coping-with method.
[0009] When the above is arranged, it will be called two points of quick attenuation ** of vibration generated as a required function of a vibrationproofing base required for an aligner inside reduction and (b) equipment of the oscillating transfer from a (b) floor line. However, coexistence is a difficult function when these two points are considered from the requirement side of a vibrationproofing base. namely, as weak as much as possible as the ground or a floor line, in order to attain reduction of the oscillating transfer from a (b) floor line -- it connects, and it is necessary to prepare rigid weak "soft vibrationproofing base" for example, and, in other words, an air spring formula vibrationproofing base is equivalent to this On the other hand, in order to attain quick attenuation of vibration generated inside (b) equipment, it is necessary to realize strong rigid "hard vibrationproofing base" where an aligner main part can vibrate united with the ground or a floor line. In order to satisfy the latter performance, a vibrationproofing base which made the rigid big mechanical spring the component, or a thing like a rubber vibration insulator will be applied.
[0010] although the above-mentioned passive vibrationproofing base by the Prior art for example, has the advantage from which a thing appropriate at a comparatively cheap price is obtained by present also by the case of the vibrationproofing base which it is a low price, and did not reach for saying in simple rubber vibration insulator use, but used the air spring, it is difficult for fully satisfying the vibrationproofing function made required for the aligner described above Moreover, a sensor is installed within and without equipment and another active vibrationproofing base can build a vibrationproofing system with which it is made to satisfy both two functions that are the above-mentioned (b) and a (b), and is fully satisfied of various military requirements by oscillating control based on this detecting signal. However, while various sensors with sufficient precision are

required, it is necessary to constitute an electronic circuitry quite complicated as a controller which controls vibrationproofing mounting. Therefore, the equipment of high cost is needed, and considering what can be applied to the highly efficient aligner demanded especially today, by present, it becomes high cost, so that profit cannot be taken.
[0011] this invention aims at offering the stage equipment of a low cost to which both two functions of quick attenuation ** of reduction of the oscillating transfer from a (b) floor line and vibration generated inside (b) equipment are satisfied in view of this point.

MEANS

[Means for Solving the Problem] The 1st stage equipment of this invention is characterized by providing the following to the stage equipment with which the movable object (6 7) was laid on the base (9). Two or more three or more periodic-damping meanses to attenuate vibration between the installation side (13) and its base (9) while supporting the base (9) on the installation side (13) of the stage equipment, respectively (12a, 12b) A damping-property adjustable means to change either [at least] the spring constant of one predetermined piece or two or more predetermined periodic-damping meanses in two or more of the periodic-damping meanses (12a, 12b), or a dumping coefficient according to the move state of the movable object (6 7) (19)
[0013] Moreover, the 2nd stage equipment of this invention has the base (9) in which the substrate stage (6 7) which moves a sensitization substrate (4) two-dimensional, and this substrate stage (6 7) are laid, and is characterized by providing the following to the stage equipment for aligners which exposes a mask pattern on the sensitization substrate (4). Two or more three or more periodic-damping meanses to attenuate vibration between the installation side (13) and its base (9) while supporting the base (9) on the installation side (13) of the stage equipment, respectively (12a, 12b) A damping-property adjustable means to change either [at least] the spring constant of one predetermined piece or two or more predetermined periodic-damping meanses in two or more of the periodic-damping meanses (12a, 12b), or a dumping coefficient according to the move state of the substrate stage (6 7) (19)
[0014] In the 1st of this invention, and the 2nd stage equipment moreover, an example of the one predetermined piece or two or more predetermined periodic-damping meanses (12a, 12b) It has the movable object (42a, 42b) arranged in predetermined viscous fluid (45), respectively, and it is desirable for the damping-property adjustable means (19) to change the viscous-drag coefficient of the viscous fluid (45), and to change a dumping coefficient in this case.
[0015] Moreover, other examples of the damping-property adjustable means (19) change a spring constant by inserting [member / (25) / spring] between the installation side (13) and its base (8) in parallel with the periodic-damping means (12a, 12b) set as the adjustable object of a damping property. Moreover, another example of a means to change the spring constant is a means to change the spring constant which the gain of a position feedback is changed, for example, a spring constant is changed indirectly, or is directly expressed with the energization force / change, when an electric actuator (31; 34) is used.

OPERATION

[Function] According to the 1st stage equipment of this this invention, according to the move state of a movable object (6 7), the spring constant or dumping coefficient of a periodic-damping means (12a, 12b) can be changed by the damping-property adjustable means (19), and the periodic-damping property of stage equipment can be changed. When it seems that he does not want to follow, for example, to transmit the vibration from the stage equipment outside to stage equipment, a spring constant can be made small and it can respond. On the other hand, it can respond by making high rigidity of stage equipment, such as enlarging a dumping coefficient, to converge quickly the vibration inside equipment which is followed on movement of a movable object (6 7).
[0017] Moreover, according to the 2nd stage equipment of this invention, two functions of quick attenuation ** of vibration generated inside reduction and (b) equipment of the oscillating transfer from a (b) floor line required as stage equipment of an aligner can both be satisfied to cheap cost. As mentioned above, it does not need to be satisfied [with this time] of two functions required as stage equipment of an aligner. It is the time when the pattern of a mask (1) bakes on a sensitization substrate (4) at, and is exposed, the time of various kinds of optical alignment operation, etc. that the function which is (**) is needed for the maximum. Moreover, it is the acceleration time and the deceleration time of a substrate stage (6 7) in the time of stepping to which a substrate stage (6 7) is moved at high speed that the function of (**) becomes important.
[0018] If it is made a setup which changes the periodic-damping property of a periodic-damping means (12a, 12b) to two kinds for example, in stage equipment there and will think from the function of an aligner, it can consider as the stage equipment with which it is satisfied of both two functions, a (b) and a (b), as a result. namely, the exposure time -- only setting -- rigidity -- "-- soft -- " -- what is necessary is just to carry out If it carries out that it cooks of the rigidity in "" to the time in connection with the acceleration slowdown of other stages, **** (setting) of the vibration generated by acceleration slowdown can be carried out quickly enough.
[0019] By the way, although such time management is performed by the damping-property adjustable means (19), a sensor and a control section special for setting change of this periodic-damping means (12a, 12b) are not needed. Namely, what is necessary is to emit a control signal according to the operation situation of an aligner from a damping-property adjustable means (19), for example, just to control operation of viscous fluid (45). Therefore, according to the 2nd stage equipment of this invention, the function which is very cheap cost compared with the above-mentioned active vibrationproofing base, and an active vibrationproofing base has can be attained.
[0020] Furthermore, the drive of the stage equipment in an aligner and the combination of a halt are not necessarily applied only in exposure operation, and are applied also in operation of delivery with the handler at the time of exchange of various kinds of optical alignment operation, a mask (1), a sensitization substrate (4), etc. As for a control parameter called the drive speed and acceleration of a substrate stage (6 7) according to each case, differing is common. therefore, the "rigidity" which should be set as a periodic-damping means (12a, 12b) -- "-- soft/-- it

is hard -- it is desirable several step story and that change of the set point of 4 - 5 stage can be performed not only according to two stages of " but according to each case if it may be able to do According to the 2nd stage equipment of this invention, two or more of these set points can be easily set up by the damping-property adjustable means (19).

EXAMPLE

Hereafter, one example of the stage equipment by this invention is explained with reference to drawing 1 - drawing 3 , and drawing 8 . this example applies this invention to the projection aligner of the step-and-repeat method which reduces the pattern on a reticle by the projection optical system, and is exposed to each shot field on a wafer.

[0022] In this drawing 1 , the outline composition of the projection aligner of this example is shown, the lighting light IL for exposure injected from the lighting optical system EL is irradiated by the lighting field on a reticle 1, the circuit pattern drawn in the lighting field is reduced through a projection optical system 3, and drawing 1 is imprinted by the front face of a wafer 4. As a lighting light IL, laser beams, such as others and KrF excimer laser light, ArF excimer laser light, etc., are used. [bright lines / (i line with a wavelength of 365nm, g line with a wavelength of 436nm, etc.) /, such as a mercury lamp,] Here, in drawing 1 , the Z-axis is taken in parallel with the optical axis AX of a projection optical system 3, and the X-axis is taken in the space of drawing 1 within a flat surface perpendicular to the optical axis AX at right angles to the space of a Y-axis and drawing 1 in parallel.

[0023] In drawing 1 , vacuum adsorption of the reticle 1 on which the circuit pattern was drawn is carried out on a reticle stage 2, and this reticle stage 2 positions a reticle 1 to the direction of X, the direction of Y, and a hand of cut (the direction of theta) within a two-dimensional flat surface (XY flat surface) perpendicular to the optical axis AX of a projection optical system 3. The position coordinate in the two-dimensional flat surface of a reticle stage 2 is always detected with the resolution of about 0.01 micrometers by the laser interferometer arranged on the outskirts of a move mirror and the outskirts on the non-illustrated reticle stage 2.

[0024] As shown in drawing 1 , a wafer 4 is held by vacuum adsorption on a non-illustrated wafer electrode holder, and the wafer electrode holder is being fixed on Z stage 5. Moreover, Z stage 5 is laid on the X stage 6 where only the length for a diameter of the greatest wafer exposed by this projection aligner can move in the direction of X, and the X stage 6 is laid on the Y stage 7 where only the length for a diameter of the greatest wafer can move in the direction of Y. A wafer stage consists of these Z stages 5, an X stage 6, a Y stage 7, and wafer base 8 grade.

[0025] It drives by the motor 15 through a feed screw 14, and moves in the direction of Y relatively to the wafer base 8, and the Y stage 7 is driven by the motor 16 through a non-illustrated feed screw, and moves in the direction of X relatively to the Y stage 7 on the X stage 6. Moreover, by the non-illustrated mechanical component, to the image formation side of a projection optical system 3, Z stage 5 can incline in the arbitrary direction, and can be moved slightly in the optical-axis AX direction (Z direction). Moreover, surrounding rotation of an optical axis AX is also possible for Z stage 5.

[0026] Furthermore, the firm measurement of the X coordinate and Y coordinate of Z stage 5 is carried out by the move mirror fixed on Z stage 5, and the laser interferometer of the non-illustrated exterior. Furthermore, the focal position

detection system of the oblique incidence method which consists of irradiation optical system which projects images, such as a pinhole or a slit pattern, aslant to an optical axis AX towards the exposure side of the wafer 4 near the image formation side of a projection optical system 3 although not illustrated, and light-receiving optical system which carries out re-image formation of the image from the projected reflected light bunch from an image is prepared. The position of the Z direction of the front face of a wafer 4 is detected by this focal position detection system, and auto-focusing is performed so that the front face of a wafer 4 may agree in the image formation side of a projection optical system 3 based on the detection information.

[0027] The aligner main part 11 which consists of surface plate 9 grades which support Z stage 5, the X stage 6, the Y stage 7 and the wafer stage that consists of wafer base 8 grades, the lighting optical system EL, a projection optical system 3, a reticle stage 2, the columns 22 and 23 that support those devices, and columns 22 and 23 as mentioned above is installed after four vibrationproofing mountings. Drawing 1 shows only two vibrationproofing mountings 12a and 12b. The vibrationproofing mountings 12a and 12b are being fixed so that a mutual position may not shift on a base plate 13. About the vibrationproofing mountings 12a and 12b, it mentions later in detail. In addition, the aligner main part 11 is equipped also with the alignment system which is not illustrated for in addition to this performing alignment of a reticle 1 and a wafer 4.

[0028] Moreover, the control system 19 (refer to drawing 2) contained in the control rack 28 of the equipment exterior also controls operation of the vibrationproofing mountings 12a and 12b while controlling the handler which is not illustrated [which performs receipt and supply of the lighting optical system EL, a reticle stage 2, a wafer stage and a wafer 4, or a reticle 1]. Next, vibrationproofing mounting 12a is explained with reference to drawing 2 . The same is said of vibrationproofing mounting 12b and other vibrationproofing mountings. In addition, the structure from which the oscillating absorbent system according [vibrationproofing mounting 12a] to a spring member and the oscillating absorbent system by viscous fluid constitute the oscillating absorbent system according the structure which constitutes the oscillating absorbent system by the spring member on account of following explanation to a spring buffer system and viscous fluid by becoming integral construction is explained as a fluid buffer system. Vibrationproofing mounting 12a of this example is the structure which consists of a spring buffer system and a fluid buffer system.

[0029] the cross section in which drawing 2 shows the internal configuration of vibrationproofing mounting 12a of this example -- it is -- this drawing 2 -- setting -- a crowning -- a member 43 is a portion connected to the aligner main part 11 of drawing 1 , and the inferior-surface-of-tongue side of a case 44 is being fixed to the base plate 13 of drawing 1 the spring which constitutes the spring buffer system of this example in the center section of the lid 48 of a case 44 -- the end of a member 20 is fixed -- having -- a spring -- the other end of a member 20 -- a crowning -- it is fixed to the member 43 moreover, a crowning -- two or more wing-like members (drawing 2 shows only two-piece 42a of them, and 42b) which constitute the fluid buffer system of this example in a member 43 -- a spring -- as a member 20 is surrounded, it is attached -- having -- **** -- a crowning -- each pedicel 49a and 49b of the wing-like members 42a and 42b fixed to the member 43 is ****(ed) to opening of a lid 48

[0030] The viscous fluid 45 which constitutes the principal part of the fluid buffer

system of this example is filled up into container 50a of the shape of a thick cylinder within a case 44 with the state where leak and there is nothing, and the wing portion of the wing-like members 42a and 42b is dipped into viscous fluid 45. Moreover, the electrode 46 of a couple was formed in the front face of a case 44, and these electrodes 46 have flowed with viscous fluid 45. if the voltage impressed between the electrodes 46 of a couple is changed from the power supply which the viscous fluid 45 used here is an ER (Electro Reological) fluid from which viscosity changes corresponding to the change of potential as mentioned later, and was prepared outside -- the viscosity of viscous fluid 45 -- changing -- consequent -- attenuation of vibrationproofing mounting 12a -- a law -- a property changes The viscosity of this viscous fluid is controlled by the control system 19 prepared in the exterior of vibrationproofing mounting 12a.

[0031] Next, the viscous fluid 45 which constitutes the fluid buffer system of this example is explained. Viscous fluid 45 is as above-mentioned electrorheological fluid from which the viscosity changes corresponding to the change of potential impressed to viscous fluid. In the state as it is, although this electrorheological fluid is the colloidal solution with a fluidity, if severalkV [/mm] electric field are applied, it will lose a fluidity in proportion to field strength, and will change to the state near a solid-state depending on the kind of electrorheological fluid. Furthermore, the speed of response of the viscous change in electrorheological fluid is about 0.1 secs, for example, has the speed of response easily applicable to the projection aligner of stepper type and step - and - scanning method.

[0032] As this electrorheological fluid, the distributed type thing which distributed the particle of electric polarization nature, and the liquid crystal type thing which used liquid crystal recently are in the fluid of insulation, such as a silicone oil. Although distributed type electrorheological fluid is cheap in price, there is a fault which the distributed particle separates out of a solution. a field where a particle does not separate liquid crystal type electrorheological fluid, in addition the ER effect is extinguished with distributed type electrorheological fluid to it and where a shear rate is high -- even when -- although there is an advantage -- the ER effect is not lost -- there is a difficulty that it is high in price Various kinds of fluids are already marketed as the above electrorheological fluid from each maker, such as Asahi Chemical Industry, Nippon Oil, NIPPON SHOKUBAI, Japanese MEKUTORON, Dow Corning, and Toray Industries.

[0033] As viscous fluid 45, change of coefficient of viscosity is [from / especially] large among the above electrorheological fluid, it is rapid response, power consumption is small, it excels in the dispersibility of a particle, and operation temperature chooses a product cheap in price widely. Next, it explains per operation of the stage equipment of this example. the oscillation characteristic of vibrationproofing mounting 12a which <u>drawing 3</u> shows the ** type view for explaining the oscillating model of vibrationproofing mounting 12a used by this example, is arranged in this <u>drawing 3</u> between the aligner main part 11 and the base plate 13 which is the installation side of an aligner, and supports the aligner main part 11 -- the spring of <u>drawing 2</u> -- spring constant [of a member 20] K, and periodic damping -- the damping coefficient C based on the viscous-drag coefficient of the viscous fluid 45 which is a member is determined

[0034] this example -- a spring -- spring constant K of a member 20 is fixed Therefore, the oscillation characteristic of vibrationproofing mounting 12a is changed by changing the damping coefficient C based on the viscous-drag coefficient of viscous fluid 45 **. In this example, electrorheological fluid is used as

viscous fluid 45. By controlling the applied voltage to viscous fluid now, the electrorheological fluid which can change the coefficient of viscosity of viscous fluid 45 by the ratio of 10 times or more is available, and can control the height of the peak of the resonance scale factor in the resonant frequency in a low frequency region, and the transmissibility of vibration in an inside RF region by applying such electrorheological fluid.

[0035] As mentioned above, it does not need to be satisfied [with this time] of two functions of quick attenuation ** of vibration generated inside reduction and (b) equipment of the oscillating transfer from a (b) floor line required as a vibrationproofing base of an aligner. It is the time when the pattern of a reticle 1 bakes on a wafer 4 at, and is exposed, the time of various kinds of optical alignment operation, etc. that the function of a (b) is needed for the maximum. Moreover, it is the acceleration-and-deceleration time of the reticle stage 2 at the time of moving a wafer stage and a reticle stage 2 at high speed, and a wafer stage that the function of a (b) becomes important.

[0036] Drawing 8 shows the graph for explaining the drive of the wafer stage in the stepper type projection aligner of this example, and the timing of exposure, Time t is shown in the horizontal axis and the speed VW of a wafer stage is shown in the vertical axis. First, a wafer stage accelerates in a period 71, uniform operation is performed between periods 72, and a wafer stage is slowed down in a period 73. The period 75 when the very small range is positioned in the period 74 just behind it in, and it is stood still after the end is the exposure time. The total time 76 is the sum of the above periods 71-75, and a drive and exposure of a wafer stage are repeated this period. Moreover, the speed VW on a vertical axis shows the highest drive speed of a wafer stage.

[0037] If it is made a setup which changes the periodic-damping property of the vibrationproofing mountings 12a and 12b to two kinds in the stage equipment of this example there and will think from the function of an aligner, it can consider as the vibrationproofing base with which it is satisfied of both two functions, a (b) and a (b), as a result. namely, the period 75 which is the exposure time -- only setting -- rigidity -- "-- soft -- " -- it carries out Namely, what is necessary is just to make viscosity of viscous fluid 45 small. Thereby, the oscillating transfer from the equipment outside is intercepted mostly. If it carries out that it cooks of the rigidity in "" to the time in connection with the acceleration slowdown of other stages, vibration generated by acceleration slowdown can be ****(ed) quickly enough.

[0038] By the way, although such time management is performed by the control system 19 of drawing 2 which controls the whole aligner, a sensor special for property change of the vibrationproofing mountings 12a and 12b of this example is not needed. Namely, what is necessary is to emit a control signal according to the operation situation of an aligner from a control system 19, and just to control the applied voltage to viscous fluid 45. Therefore, according to the stage equipment of this example, the function which is very cheap cost compared with an active vibrationproofing base, and an active vibrationproofing base has can be attained.

[0039] Furthermore, the drive of stages, such as the reticle stage 2 in an aligner and a wafer stage, and the combination of a halt are not necessarily applied only in exposure operation, and are applied also in operation of delivery with the handler at the time of exchange of various kinds of optical alignment operation, a wafer 4, and reticle 1 grade etc. As for a control parameter called the drive speed and acceleration of a stage according to each case, differing is common. therefore, the "rigidity" which should be set as the vibrationproofing mountings 12a and 12b -- "--

soft/-- it is hard -- it is desirable several step story and that change of the set point of 4 - 5 stage can be performed not only according to two stages of " but according to each case if it may be able to do By the method to which the viscosity of the viscous fluid 45 of this example is changed, since the rigidity can be continuously changed by predetermined within the limits, two or more of these set points can be easily set up by the control system 19.

[0040] Next, other examples of the stage equipment by this invention are explained with reference to drawing 4 . Drawing 4 shows the ** type view for explaining the oscillating model of vibrationproofing mounting 21a of this example. vibrationproofing mounting 12a [in / the example of drawing 1 / in this example] -- replacing with -- damping coefficient C 1 the spring which it is fixed and is a thing using vibrationproofing mounting 21a to which a spring constant can be changed, and was united with the fluid buffer system by viscous fluid 45A as shown in drawing 4 -- a member -- 20A -- adding -- the near -- a piece or two or more springs -- it has prepared free / insertion and detachment of a member 25 in this case, a spring -- even if it unites with the fluid buffer system by viscous fluid 45A and a member 25 is not, whichever is sufficient as it In addition, also in the stage equipment of this example, four vibrationproofing mountings are prepared like drawing 1 .

[0041] drawing 4 -- setting -- a piece or two or more springs -- although the end of a member 25 is being fixed to the base plate 13, the other end does not always contact in the aligner main part 11, but control which connects and releases the field 26 where the other end and aligner main part 11 face with a driving gear 27 is performed As a driving gear 27 which performs this connection and release operation, various drive systems, such as machine operation by use of electromagnetic force, a vacuum adsorption power, and pneumatic pressure, the motor, etc., can be used. Connection of a driving gear 27 and control of release are performed by the control system 19. Other composition is the same as the stage equipment of drawing 1 .

[0042] The oscillating model of drawing 4 explains operation of vibrationproofing mounting of this example briefly. in addition, the case where two or more spring members are prepared in vibrationproofing mounting 21a -- those springs -- although the spring constants of a member differ, respectively -- spring constant K2 It represents and explains. namely, a spring -- the number of change by the combination of the number of members 25 -- spring constant K2 It shall change. In addition, operation of viscous fluid 45A is not controlled by the control system 19, but most viscous-drag coefficients of viscous fluid 45A are governed by only environmental temperature. Therefore, at ordinary temperature, it is the damping coefficient C 1. It thinks as fixed.

[0043] the damping property by viscous fluid 45A in which vibrationproofing mounting 21a has a damping property -- adding -- a spring -- a member -- spring constant K1 of 20A a spring -- spring constant K2 of a member 25 Spring constant KT by combination By making it change, further many oscillation characteristic values can be set up as compared with the example of drawing 1 . a spring -- if the number of members 25 is set to n -- spring constant K2 several [of change] -- combination about which P takes i pieces from n pieces nCi ** -- it carries out and is set to (1+nC1+nC2+--+nCn) at the maximum

[0044] for example, a spring -- if the number of members 25 is three -- spring constant K2 The number of change is set to 8 at the maximum. spring constant KT although change is not continuous -- the spring of the predetermined number --

forming a member 25 -- spring constant KT of the form almost near continuation It can also obtain. therefore, a spring -- member 20A and two or more springs -- it can respond to the demand of various oscillation characteristics to stage equipment with the combination of a member 25 and viscous fluid 45A

[0045] in addition -- this example -- vibrationproofing mounting 21a -- a spring -- although constituted by the combination of the spring buffer system by members 20A and 25, and the fluid buffer system by viscous fluid 45A, there may not be a fluid buffer system However, it is more more effective to apply combining both spring buffer system and fluid buffer system. Next, another example of the stage equipment by this invention is explained with reference to drawing 5 . that to which this example changes the spring constant of vibrationproofing mounting like the example of drawing 4 -- it is -- a spring constant -- K3 a spring -- a member -- the spring buffer system and the damping coefficient C 2 by 20B The vibrationproofing mounting 30 of the assistance which used the actuator 31 of a voice coil motor (henceforth "VCM") method near the vibrationproofing mounting 28a which consists of fluid buffer systems by viscous fluid 45B is formed. In addition, also in the stage equipment of this example, four vibrationproofing mountings are prepared like the example of drawing 1 .

[0046] The vibrationproofing mounting 30 of the assistance by which the lower part was fixed to the base plate 13 near the vibrationproofing mounting 28a as drawing 5 showed the ** type view for explaining the oscillating model of vibrationproofing mounting of this example and it was shown in drawing 5 is installed. The VCM actuator 31 which constitutes the vibrationproofing mounting 30 consists of magnet section 31b fixed to coil section 31a and vibrationproofing mounting 30a which were fixed to the aligner main part 11, and the energization force over the aligner main part 11 changes from a base plate 13 according to the current passed to coil section 31a.

[0047] The position of the aligner main part 11 is faced and established in the pars basilaris ossis occipitalis of the aligner main part 11, and it is measured by position-sensor 33A which detects the position (height) of buckling-of-track section 11a of the pars basilaris ossis occipitalis of the aligner main part 11. Position-sensor 33A is being fixed to the base plate 13 through support frame 38A, and the physical relationship of position-sensor 33A and a base plate 13 is fixed. The measurement value of position-sensor 33A is supplied to position gain circuit 39A, and the VCM actuator 31 of the auxiliary vibrationproofing mounting 30 is controlled by position gain circuit 39A to generate the energization force in predetermined gain in the direction which sets the amount of gaps of the measurement value of position-sensor 33A to 0. And in this example, when a control system 19 changes the gain of the position in position gain circuit 39A, the spring constant of the VCM actuator 31 is changed indirectly. Moreover, although various length measurement sensors can be used as position-sensor 33A, use of a laser reflection type sensor, an eddy current sensor, etc. is desirable from a cost-side. Other composition is the same as that of the stage equipment of drawing 1 .

[0048] Next, still more nearly another example of the stage equipment by this invention is explained with reference to drawing 6 . This example is what used the actuator of a feed screw method by motorised as vibrationproofing mounting, and has not prepared vibrationproofing mounting which consists of a spring buffer system like the above-mentioned example, and a fluid buffer system in this example. In addition, also in the stage equipment of this example, four vibrationproofing mountings are prepared like drawing 1 .

[0049] Drawing 6 shows the ** type view for explaining the oscillating model of vibrationproofing mounting of this example, and vibrationproofing mounting 32a by which the lower part was fixed to the base plate 13 is installed in this drawing 6 . The actuator 34 of the electric type which constitutes the drive of vibrationproofing mounting 32a consists of drive-motor 34b turning around thread-part 34a screwed in the nut section of spindle 34c which runs against field 26A which the aligner main part 11 counters, and this spindle 34c, and this thread-part 34a etc. It is fixed to a base plate 13 and the pars basilaris ossis occipitalis of vibrationproofing mounting 32a has composition which absorbs the vibration from the aligner main part 11.
[0050] The position of the aligner main part 11 is measured like the stage equipment of drawing 5 by position-sensor 33A which detects the position of buckling-of-track section 11a of the pars basilaris ossis occipitalis of the aligner main part 11. The measurement value of position-sensor 33A is supplied to position gain circuit 39B, and position gain circuit 39B controls the energization force over the aligner main part 11 of an actuator 34 by position gain to set the amount of gaps of the measurement value of position-sensor 33A to 0. Also by this example, a control system 19 adjusts the position gain in the position gain circuit 39B, and changes the spring constant in an actuator 34. Other composition is the same as the stage equipment of drawing 1 .
[0051] Unlike the VCM actuator 31 of drawing 5 , the actuator 34 which consists of the feed screw and drive motor of this example is independently applicable also to the big equipment of a load. However, you may use together with vibrationproofing mounting which consists of other spring buffer systems or fluid buffer systems. Next, the modification of the stage equipment of drawing 5 is explained with reference to drawing 7 . This example allots a load cell between the vibrationproofing mountings 30 and the aligner main parts 11 of assistance of drawing 5 .
[0052] Drawing 7 shows the ** type view for explaining the oscillating model of vibrationproofing mounting of this example, and the load cell 35 is arranged in drawing 7 between the base of the aligner main part 11, and the upper surface of the outer case of the vibrationproofing mounting 30 which has the VCM actuator 31. The measured value of the load from a load cell 35 is supplied to drive circuit 39C, and the measurement result of the position from position-sensor 33A is also supplied to drive circuit 39C. Drive circuit 39C controls the energization force of the VCM actuator 31 to make into a predetermined value the spring constant which is the load detected by the load cell 35, i.e., the value which **(ed) the force in the amount of gaps (variation rate) detected by displacement-sensor 33A. Moreover, a control system 19 makes the value of the spring constant in the drive circuit 39C change if needed. Other composition is the same as that of the stage equipment of drawing 5 .
[0053] The oscillating model of drawing 7 explains operation of vibrationproofing mounting of this example briefly. the damping property by viscous fluid 45B in which vibrationproofing mounting of this example has a damping property -- adding -- a spring -- a member -- spring constant K3 of 20B the spring of the VCM actuator 31 which constitutes the auxiliary vibrationproofing mounting 30 -- constant -- several kA Spring constant KT by combination Various damping properties can be set up by making it change.
[0054] If the force concerning a load cell 35 is made into applied force F and the amount of gaps of the position of the aligner main part 11 measured by position-

sensor 33A is made into a variation rate delta x, the value (F/delta x) which **(ed) applied force F by delta x is equivalent to the usual spring constant, when the VCM actuator 31 is regarded as a spring material. therefore, a spring -- constant -- several kA (F/delta x) -- it is -- a spring -- constant -- several kA What is necessary is just to change the applied force F to the same variation rate delta x into changing. therefore, the thing for which the current passed to coil 31a by the control system 19 is controlled -- the spring of the VCM actuator 31 -- constant -- several kA It is changeable.

[0055] It is the spring constant KT of the whole stage equipment only by controlling the VCM actuator 31 by drive circuit 39C electrically, since the vibrationproofing mounting 30 of assistance by the VCM actuator 31 is formed according to the method of this example. It can be made to be able to change broadly and can respond to the demand of various oscillation characteristics to stage equipment. According to the stage equipment by the above example, vibrationproofing mounting which consists of a spring buffer system and a fluid buffer system can be installed between the base plates 13 used as the aligner main part 11 and the installation side of an aligner, vibration from which various [, such as vibration accompanying movement of the reticle stage 2 of an aligner or a wafer stage and vibration from the installation side of an aligner,] differ can be buffered, and the performance of an aligner can be raised.

[0056] In addition, you may use an air spring as a spring member in an above-mentioned example. Moreover, the buffer system which used air, such as for example, a pneumatics cylinder, as a fluid buffer system can also be used. In addition, although the above-mentioned example applies the stage equipment of this invention to a stepper type projection aligner, it is also applicable to the aligner of step - which synchronizes and scans a reticle and a wafer, and - scanning method.

[0057] Drawing 9 shows the graph for explaining the drive of the wafer stage of the aligner of step - and - scanning method, and the timing of exposure, Time t is shown in the horizontal axis and the speed VW of a wafer stage is shown in the vertical axis. As shown in drawing 9 , in a period 77, a wafer stage accelerates, and performs convergence to a predetermined scan speed in the period 78 just behind it, and exposure is performed in the period 79 when a scan speed becomes fixed. The wafer stage between periods 79 is a scan speed VW2. It moves. After exposure is completed, a wafer stage is slowed down in a period 80. In the period 81 just behind it, positioning to the scanning starting position of the following exposure shot is performed. The total time 82 is the sum of the above periods 77-81, and a drive and exposure of a wafer stage are repeated this period.

[0058] the period 79 which is the exposure time like stepper type stage equipment -- only setting -- rigidity -- "-- soft -- " -- what is necessary is just to carry out If it carries out that it cooks of the rigidity in "" to the time in connection with the acceleration slowdown of other stages, vibration generated by acceleration slowdown can be ****(ed) quickly enough. Moreover, in the above-mentioned example, although the helical compression spring is used as a spring member, you may use flat spring, a griddle, etc.

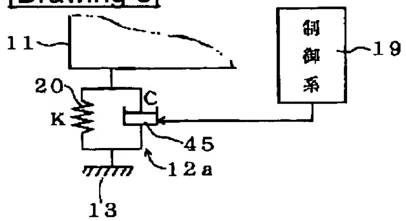
[0059] Thus, this invention is not limited to the above-mentioned example, but can take composition various in the range which does not deviate from the summary of this invention.

DESCRIPTION OF DRAWINGS

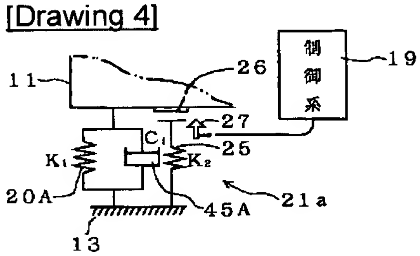
[Drawing 1] It is the outline block diagram showing one example of the aligner to which the stage equipment by this invention was applied.
[Drawing 2] It is the cross section showing the internal configuration of vibrationproofing mounting 12a of drawing 1 .
[Drawing 3] It is the ** type view showing the oscillating model of vibrationproofing mounting 12a of drawing 1 .
[Drawing 4] It is the ** type view showing the oscillating model of other examples of the stage equipment of this invention.
[Drawing 5] It is the ** type view showing the oscillating model of another example of other of the stage equipment of this invention.
[Drawing 6] It is the ** type view of the stage equipment of this invention showing the oscillating model of another example of other further.
[Drawing 7] It is the ** type view showing the oscillating model of the modification of the stage equipment of drawing 5 .
[Drawing 8] It is drawing showing the state of the speed control of the wafer stage of the aligner of drawing 1 .
[Drawing 9] It is drawing showing the state of the speed control of the wafer stage of the aligner of step - and - scanning method.
[Drawing 10] It is the outline block diagram showing an example of the aligner to which conventional stage equipment was applied.
[Drawing 11] It is the outline block diagram showing other examples of the aligner to which conventional stage equipment was applied.
[Description of Notations]
1 Reticle
2 Reticle Stage
3 Projection Optical System
4 Wafer
6 X Stage
7 Y Stage
8 Wafer Base
9 Surface Plate
11 Aligner Main Part
12a, 12b, 21a, 28a, 30, 32a Vibrationproofing mounting
13 Base Plate
19 Control System
20, 20A, 20B, and 25 a spring -- member
45, 45A, 45B Viscous fluid
27 Drive System
42a, 42b Wing-like member
31 Voice Coil Motor (VCM) Formula Actuator
33A Position sensor
34 Feed Screw Formula Actuator
39A Position gain circuit
35 Load Cell

DRAWINGS

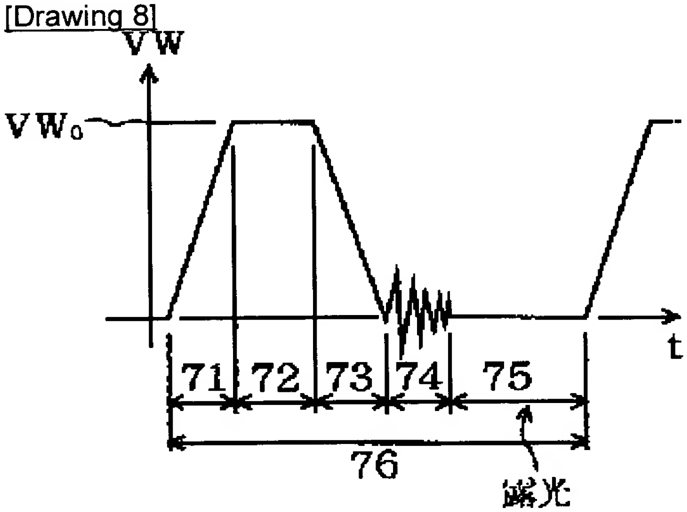
[Drawing 3]



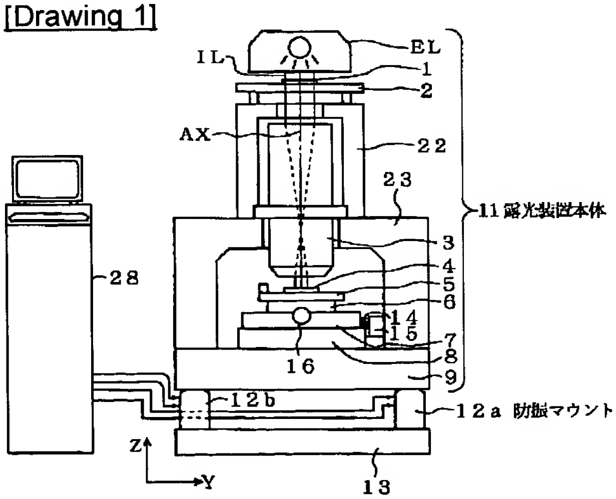
[Drawing 4]



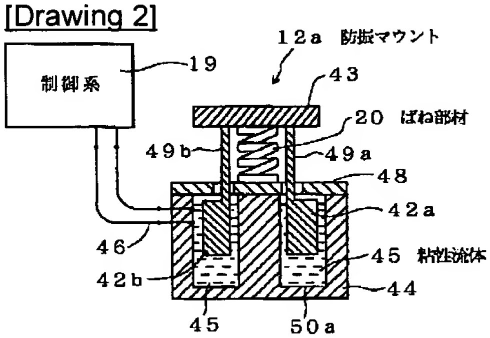
[Drawing 8]



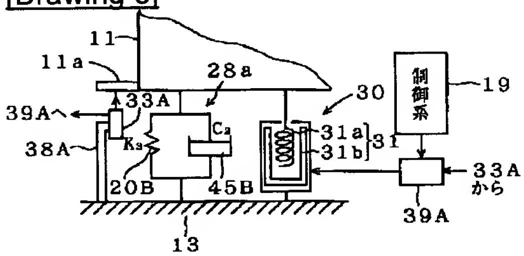
[Drawing 1]



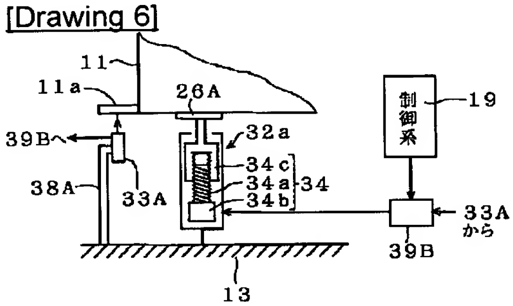
[Drawing 2]



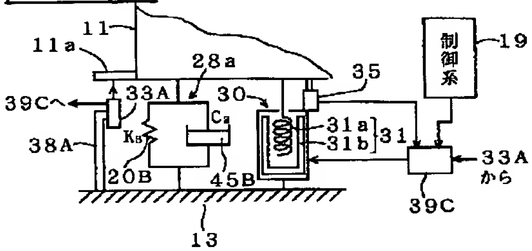
[Drawing 5]



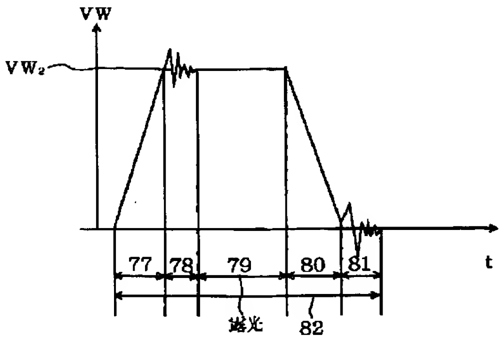
[Drawing 6]



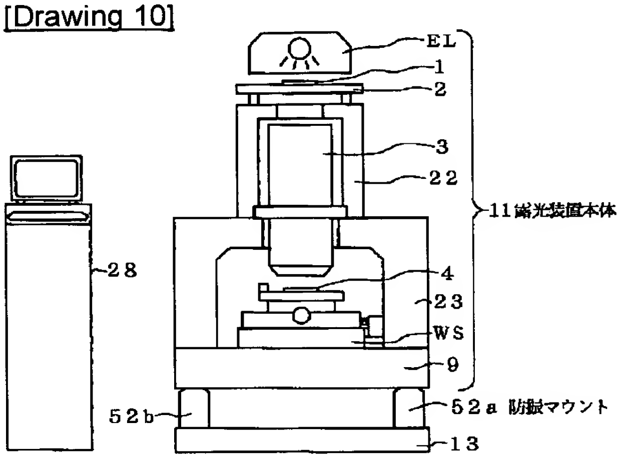
[Drawing 7]



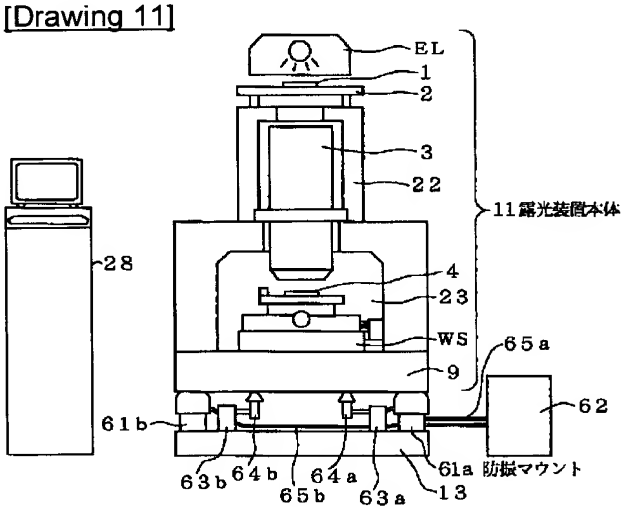
[Drawing 9]



[Drawing 10]



[Drawing 11]



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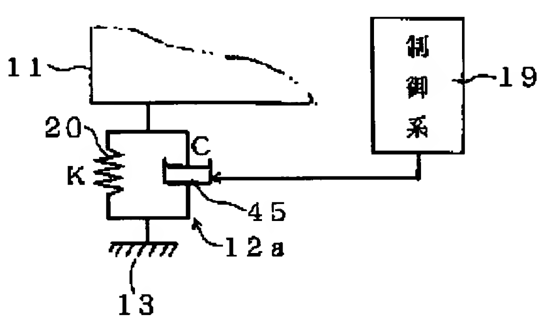
(71)出願人　000004112
株式会社ニコン
東京都千代田区丸の内３丁目２番３号

(72)発明者　坂本　英昭
東京都千代田区丸の内３丁目２番３号　株式会社ニコン内

(74)代理人　弁理士　大森　聡

(54)【発明の名称】　ステージ装置

(57)【要約】
【目的】　露光装置等に使用される揺れや振動の制御機構を有するステージ装置において、コストを高くすることなく、ステージ装置の剛性を可変にする。
【構成】　ウエハステージ等を搭載する露光装置本体１１とベースプレート１３との間で露光装置本体１１を支持する防振台として、ばね部材２０によるばね緩衝系及び粘性流体４５による流体緩衝系から構成される防振マウント１２ａを用いる。粘性流体４５として電界により粘性抵抗係数が変化するＥＲ（Electro Reological）流体を用い、制御系１９により粘性流体４５の粘性抵抗係数に基づくダンピング係数を変化させることにより、防振マウント１２ａの剛性を可変にし、装置外の振動及びステージの移動に伴う振動等に対して、それぞれ防振マウント１２ａの剛性を変えて対応する。



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【特許請求の範囲】

【請求項１】 可動体がベース上に載置されたステージ装置において、
前記ステージ装置の設置面上でそれぞれ前記ベースを支持すると共に、前記設置面と前記ベースとの間の振動を減衰させる３個以上の複数個の振動減衰手段と、
前記可動体の移動状態に応じて、前記複数個の振動減衰手段中の所定の１個又は複数個の振動減衰手段のばね定数、及びダンピング係数の少なくとも一方を変化させる減衰特性可変手段と、を設けたことを特徴とするステージ装置。

【請求項２】 感光基板を２次元的に移動する基板ステージと、該基板ステージが載置されるベースとを有し、前記感光基板上にマスクパターンを露光する露光装置用のステージ装置において、
前記ステージ装置の設置面上でそれぞれ前記ベースを支持すると共に、前記設置面と前記ベースとの間の振動を減衰させる３個以上の複数個の振動減衰手段と、
前記基板ステージの移動状態に応じて、前記複数個の振動減衰手段中の所定の１個又は複数個の振動減衰手段のばね定数、及びダンピング係数の少なくとも一方を変化させる減衰特性可変手段と、を設けたことを特徴とするステージ装置。

【請求項３】 前記所定の１個又は複数個の振動減衰手段はそれぞれ所定の粘性流体中に配置された可動体を有し、前記減衰特性可変手段は前記粘性流体の粘性抵抗係数を変化させてダンピング係数を変化させることを特徴とする請求項１又は２記載のステージ装置。

【請求項４】 前記減衰特性可変手段は、減衰特性の可変対象となる前記振動減衰手段と並列に前記設置面と前記ベースとの間にばね部材を挿脱することによりばね定数を変化させることを特徴とする請求項１又は２記載のステージ装置。

【請求項５】 前記所定の１個又は複数個の振動減衰手段はそれぞれ前記設置面から前記ベースに対する付勢力を与える電気的アクチュエータを有し、前記減衰特性可変手段は前記電気的アクチュエータにおけるばね定数を変化させることを特徴とする請求項１又は２記載のステージ装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、揺れや振動の抑制機構を有するステージ装置に関し、特に感光材料が塗布されたウエハ等の感光基板にマスク上のパターンを焼付け露光する露光装置のステージ装置に適用して好適なものである。

【０００２】

【従来の技術】従来、例えば半導体の集積回路や液晶表示素子の製造に使用される露光装置においては、マスク（レチクル等）上のパターンをフォトレジストが塗布された基板（ウエハ、ガラスプレート等）上に高精度に転写する必要があり、マスクや基板での揺れや振動を極力抑えることが求められている。

2

【０００３】そのため、従来よりこの種の装置では振れや振動の伝達の低減を目的として、装置全体が防振台の上に搭載されるような構成をとっている。その一例を図１０を参照して説明する。図１０は、従来の露光装置の一例の概略構成図を示し、この図１０において、ウエハ４が載置されたウエハステージＷＳ、投影光学系３、レチクル１を載置するレチクルステージ２、照明光学系ＥＬ、及びそれらの部材を支持するコラム２２，２３、コラム２２，２３を支持する定盤９等からなる露光装置本体１１は、露光装置本体１１の底部に配置された３個又は４個の防振マウントによって支持されている。図１０においては、その内２個の防振マウント５２ａ、５２ｂだけを示す。なお、照明光学系ＥＬ、レチクルステージ２、ウエハステージＷＳ、及びウエハ４やレチクル１の収納及び供給を行う不図示のハンドラー等を制御する制御系が収納された制御ラック２８は、露光装置本体１１とは別の場所に配置されている。

【０００４】防振マウント５２ａ，５２ｂは、ベースプレート１３の上に互いの位置がずれないように固定されている。これらの防振マウント５２ａ、５２ｂは、通常ばね材料と振動減衰材との組合わせによって構成されている。この図１０に示すような防振システムは、振動状態によって、あるいは装置の状態（姿勢等）によって防振性能を変えることのない、いわば受動的な防振システムといえる。こういった防振台は一般的に「パッシブ防振台」と呼ばれる。

【０００５】図１１は、従来の露光装置の別の例を示す概略構成図であり、この図１１において、露光装置本体１１は上記の例と同じように複数の防振マウントにより支持されている。図１１では、その内２個の防振マウント６１ａ，６１ｂを示す。図１１の露光装置の防振マウント６１ａ，６１ｂは、空気ばね（エアーダンパ）を使用したものである。露光装置の外部に３～１０ｋｇｆ／ｃｍ^2（ゲージ圧）の正圧供給源６２を持ち、防振マウント６１ａ，６１ｂに設けられたゴム等によって密閉された空気室内にそれぞれ空気配管６５ａ，６５ｂを介して空気を送り込むことによって空気ばねを構成している。

【０００６】なお、防振マウント６１ａ，６１ｂの空気の注入口の直前にはそれぞれ流量調整弁６３ａ、６３ｂが設けられている。これらの流量調整弁６３ａ、６３ｂは、露光装置本体１１の姿勢を検知する機械式又は電気式等の間隔測定器であるレベルセンサ６４ａ，６４ｂとそれぞれ連動して作動するようになっている。即ち、露光装置本体１１の姿勢の変動によって、各々の防振マウント６１ａ，６１ｂに供給される空気の流量が変動し、結果的に露光装置本体１１の姿勢を一定に保持すること

ができるようになっている。その他の箇所は図１０と同じである。本例の防振マウント６１ａ，６１ｂも図１０の例と同様に「パッシブ防振台」と呼ばれている。

【０００７】これに対して，外部又は内部の振動状態をリアルタイムに加速度計又は変位計等のセンサによって検出し，積極的に防振マウントの性能を変動させる「アクティブ防振台」も最近使用されるようになってきている。

【０００８】

【発明が解決しようとする課題】しかしながら，特に最近の露光装置では、更に精密に揺れや振動を制御する必要に迫られており、上記の従来技術では、性能面及び価格面共に満足する防振台が得られていない。即ち，露光装置では外部，特に床面からの揺れや振動に加えて、ウエハ等の被露光部材、あるいはマスク（レチクル等）を高速に移動するステージの動作に伴う揺れや振動を考慮しなければならない。このステージの加速及び減速時には，作用反作用の関係から大きな反力が露光装置に加えられる。この反力が、防振台上の装置本体の振動発生源となる。物理的に、装置構成を大きく変えることなしにこの発生振動をゼロにすることはかなり難しく，対処法としては「できるだけ振動減衰性能を大きくし，できるだけ速く振動を減衰させる」ことに帰着する。

【０００９】以上を整理すると、露光装置に必要な防振台の必要機能としては、（イ）床面からの振動伝達の低減及び（ロ）装置内部で発生する振動の速い減衰，の２点ということになる。ところが、この２点を防振台の必要性能の側から考えると，両立は難しい機能である。即ち，（イ）床面からの振動伝達の低減，を達成するためには，大地又は床面とできるだけ弱い接続、言い換えれば，剛性の弱い「柔らかい防振台」を用意する必要があり，例えば空気ばね式防振台がこれに相当する。一方、（ロ）装置内部で発生する振動の速い減衰、を達成するためには、大地又は床面と一体となって露光装置本体が振動できるような、剛性の強い「かたい防振台」を実現する必要がある。後者の性能を満足させるためには、剛性の大きな機械式ばねを構成要素としたような防振台、あるいは防振ゴムのようなものを適用することになる。

【００１０】従来の技術による例えば前述のパッシブ防振台は、低価格で、単純な防振ゴム使用の場合は言うに及ばず、空気ばねを利用した防振台の場合でも現行で比較的廉価な価格でそれなりのものが得られる利点があるが，以上に述べた露光装置に必要とされる防振機能を十分に満足することは難しい。また、もう一方のアクティブ防振台は、装置の内外にセンサを設置し、この検出信号に基づく振動制御により，上記（イ）及び（ロ）の２つの機能を共に満足させるようにしたものであり，種々の要求性能を十分に満足するような防振システムを構築することが可能である。しかしながら，十分な精度を持った各種センサが要求されると共に，防振マウントを制御するコントローラとしてかなり複雑な電子回路を構成する必要がある。従って，高いコストの装置が必要となり，特に、今日要求されている高性能の露光装置に適用できるようなものを考えると、現行では採算が採れない程に高コストとなる。

【００１１】本発明は斯かる点に鑑み，（イ）床面からの振動伝達の低減、及び（ロ）装置内部で発生する振動の速い減衰、の２つの機能を共に満足させる低コストのステージ装置を提供することを目的とする。

【００１２】

【課題を解決するための手段】本発明による第１のステージ装置は、可動体（６，７）がベース（９）上に載置されたステージ装置において、そのステージ装置の設置面（１３）上でそれぞれそのベース（９）を支持すると共に，その設置面（１３）とそのベース（９）との間の振動を減衰させる３個以上の複数個の振動減衰手段（１２ａ，１２ｂ）と、その可動体（６，７）の移動状態に応じて、その複数個の振動減衰手段（１２ａ，１２ｂ）中の所定の１個又は複数個の振動減衰手段のばね定数、及びダンピング係数の少なくとも一方を変化させる減衰特性可変手段（１９）とを設けたものである。

【００１３】また、本発明による第２のステージ装置は，感光基板（４）を２次元的に移動する基板ステージ（６，７）と，この基板ステージ（６，７）が載置されるベース（９）とを有し，その感光基板（４）上にマスクパターンを露光する露光装置用のステージ装置において，そのステージ装置の設置面（１３）上でそれぞれそのベース（９）を支持すると共に、その設置面（１３）とそのベース（９）との間の振動を減衰させる３個以上の複数個の振動減衰手段（１２ａ，１２ｂ）と，その基板ステージ（６，７）の移動状態に応じて、その複数個の振動減衰手段（１２ａ，１２ｂ）中の所定の１個又は複数個の振動減衰手段のばね定数、及びダンピング係数の少なくとも一方を変化させる減衰特性可変手段（１９）とを設けたものである。

【００１４】また、本発明の第１及び第２のステージ装置において、その所定の１個又は複数個の振動減衰手段（１２ａ，１２ｂ）の一例は、それぞれ所定の粘性流体（４５）中に配置された可動体（４２ａ，４２ｂ）を有するものであり，この場合，その減衰特性可変手段（１９）はその粘性流体（４５）の粘性抵抗係数を変化させてダンピング係数を変化させることが好ましい。

【００１５】また、その減衰特性可変手段（１９）の他の例は、減衰特性の可変対象となるその振動減衰手段（１２ａ，１２ｂ）と並列にその設置面（１３）とそのベース（８）との間にばね部材（２５）を挿脱することによりばね定数を変化させるものである。また，そのばね定数を変化させる手段の別の例は，電気的なアクチュエータ（３１；３４）を使用した場合において，例えば位置フィードバックのゲインを変えて間接的にばね定数

を変化させるか、又は直接に付勢力／変化で表されるばね定数を変化させる手段である。

【0016】

【作用】斯かる本発明の第1のステージ装置によれば、可動体（6，7）の移動状態に応じて、振動減衰手段（12a，12b）のばね定数又はダンピング係数を減衰特性可変手段（19）により変化させて、ステージ装置の振動減衰特性を変えることができる。従って例えばステージ装置に対するステージ装置外部からの振動を伝達したくないような場合には、ばね定数を小さくして対応することができる。一方、例えば可動体（6，7）の移動に伴うような装置内部での振動を速く収束させたい場合には、ダンピング係数を大きくする等ステージ装置の剛性を高くすることにより対応することができる。

【0017】また、本発明の第2のステージ装置によれば、露光装置のステージ装置として必要な（イ）床面からの振動伝達の低減及び（ロ）装置内部で発生する振動の速い減衰、の2つの機能を共に安いコストで満足させることができる。前述のように、露光装置のステージ装置として必要な2つの機能は、同時刻に満足する必要がないものである。（イ）の機能が最大限に必要となるのは、マスク（1）のパターンが感光基板（4）に焼付け露光される時間、及び各種の光学的アライメント動作の時間等である。また、（ロ）の機能が重要となるのは、基板ステージ（6，7）を高速に移動させるステッピング時での基板ステージ（6，7）の加速時間及び減速時間である。

【0018】そこで、例えばステージ装置において、振動減衰手段（12a，12b）の振動減衰特性を2通りに変化させる設定にすれば、露光装置の機能から考えると、結果的に（イ）及び（ロ）の2つの機能を共に満足するステージ装置とすることができる。即ち、露光時間においてのみ剛性を「柔らかく」すればよい。その他のステージの加速減速に関わる時間に剛性を「かたく」しておけば、加速減速によって発生する振動は十分に速く静定（整定）することができる。

【0019】ところで、これらの時間管理は減衰特性可変手段（19）により行われるが、この振動減衰手段（12a，12b）の設定変更のために特別なセンサ及び制御部を必要としない。即ち、減衰特性可変手段（19）から露光装置の運転状況に応じて制御信号を発し、例えば粘性流体（45）の動作を制御すればよい。従って、本発明の第2のステージ装置によれば前述のアクティブ防振台に比べ非常に安いコストで且つアクティブ防振台が有する機能を達成することができる。

【0020】更に、露光装置におけるステージ装置の駆動及び停止の組み合わせは、露光動作においてのみ適用されるわけではなく、各種の光学的なアライメント動作、並びにマスク（1）及び感光基板（4）等の入れ替え時のハンドラとの受渡し等の動作においても適用される。それぞれの場合に応じて、基板ステージ（6，7）の駆動速度及び加速度といった制御パラメータは異なっているのが普通である。従って、振動減衰手段（12a，12b）に設定されるべき「剛性」は「柔らかい／かたい」の2段階だけでなく、各ケースに応じて数段階、でき得れば4～5段階の設定値の変更ができることが好ましい。本発明の第2のステージ装置によれば、これらの複数の設定値を減衰特性可変手段（19）により容易に設定することができる。

【0021】

【実施例】以下、本発明によるステージ装置の一実施例について図1～図3及び図8を参照して説明する。本実施例は、レチクル上のパターンを投影光学系により縮小してウエハ上の各ショット領域に露光するステップ・アンド・リピート方式の投影露光装置に本発明を適用したものである。

【0022】図1は、本実施例の投影露光装置の概略構成を示し、この図1において、照明光学系ELから射出された露光用の照明光ILが、レチクル1上の照明領域に照射され、その照明領域内に描画された回路パターンが、投影光学系3を介して縮小されてウエハ4の表面に転写される。照明光ILとしては、水銀ランプ等の輝線（波長365nmのi線や波長436nmのg線等）の他、KrFエキシマレーザ光及びArFエキシマレーザ光等のレーザ光が用いられる。ここで、図1において、投影光学系3の光軸AXに平行にZ軸を取り、その光軸AXに垂直な平面内で図1の紙面に平行にY軸、図1の紙面に垂直にX軸を取る。

【0023】図1において、回路パターンの描かれたレチクル1は、レチクルステージ2上に真空吸着され、このレチクルステージ2は、投影光学系3の光軸AXに垂直な2次元平面（XY平面）内で、X方向、Y方向及び回転方向（θ方向）にレチクル1を位置決めする。レチクルステージ2の2次元平面内の位置座標は、不図示のレチクルステージ2上の移動鏡及び周辺に配置されたレーザ干渉計により、例えば0．01μm程度の分解能で常時検出されている。

【0024】図1に示すように、ウエハ4は不図示のウエハホルダ上に真空吸着により保持され、ウエハホルダは、Zステージ5上に固定されている。また、Zステージ5は、この投影露光装置で露光される最大のウエハの直径分の長さだけX方向に移動可能なXステージ6上に載置され、Xステージ6は、最大のウエハの直径分の長さだけY方向に移動可能なYステージ7上に載置されている。これらのZステージ5、Xステージ6、Yステージ7、及びウエハベース8等からウエハステージが構成される。

【0025】Yステージ7は、送りねじ14を介してモータ15により駆動され、ウエハベース8に対して相対的にY方向に移動し、Xステージ6は、不図示の送りね

じを介してモータ１６により駆動され，Ｙステージ７に対して相対的にＸ方向に移動する。また，Ｚステージ５は，不図示の駆動部により，投影光学系３の結像面に対し，任意方向に傾斜可能で，且つ光軸ＡＸ方向（Ｚ方向）に微動できる。また，Ｚステージ５は光軸ＡＸの回りの回転も可能である。

【００２６】更に、Ｚステージ５上に固定された移動鏡，及び不図示の外部のレーザ干渉計により、Ｚステージ５のＸ座標及びＹ座標が常時測定されている。更に、不図示であるが投影光学系３の結像面付近のウエハ４の露光面に向けて，光軸ＡＸに対して斜めにピンホール、あるいはスリットパターン等の像を投影する照射光学系と，その投影された像からの反射光束よりその像を再結像する受光光学系とからなる斜入射方式の焦点位置検出系が設けられている。ウエハ４の表面のＺ方向の位置は，この焦点位置検出系によって検出され、その検出情報に基づきウエハ４の表面が投影光学系３の結像面に合致するようにオートフォーカスが行われる。

【００２７】以上のようにＺステージ５、Ｘステージ６，Ｙステージ７、及びウエハベース８等から構成されるウエハステージ，照明光学系ＥＬ，投影光学系３、レチクルステージ２、並びにそれらの機器を支持するコラム２２，２３，及びコラム２２、２３を支持する定盤９等から構成される露光装置本体１１は，４個の防振マウントの上に設置されている。図１ではこの内２つの防振マウント１２ａ，１２ｂだけを示す。防振マウント１２ａ、１２ｂは，ベースプレート１３の上に互いの位置がずれないように固定されている。防振マウント１２ａ，１２ｂについては詳細に後述する。なお、露光装置本体１１には、その他レチクル１とウエハ４との位置合わせを行うための不図示のアライメント系も備えられている。

【００２８】また、装置外部の制御ラック２８内に収納された制御系１９（図２参照）は、照明光学系ＥＬ、レチクルステージ２、ウエハステージ，並びにウエハ４やレチクル１の収納及び供給を行う不図示のハンドラー等を制御すると共に防振マウント１２ａ，１２ｂの動作も制御する。次に，防振マウント１２ａについて図２を参照して説明する。防振マウント１２ｂ及びその他の防振マウントについても同様である。なお，防振マウント１２ａは、ばね部材による振動吸収系と粘性流体による振動吸収系とが一体構造となったものであり，以下説明の都合上，ばね部材による振動吸収系を構成する構造体をばね緩衝系、粘性流体による振動吸収系を構成する構造体を流体緩衝系として説明する。本例の防振マウント１２ａは、ばね緩衝系と流体緩衝系とから構成される構造体である。

【００２９】図２は、本例の防振マウント１２ａの内部構成を示す断面図であり，この図２において、頂部部材４３は、図１の露光装置本体１１に接続されている部分であり、ケース４４の下面側が図１のベースプレート１３に固定されている。ケース４４の蓋４８の中央部に本例のばね緩衝系を構成するばね部材２０の一端が固定され，ばね部材２０の他端は頂部部材４３に固定されている。また，頂部部材４３には，本例の流体緩衝系を構成する複数の羽根状部材（図２ではそれらの内の２個４２ａ，４２ｂのみを示す）がばね部材２０を囲むようにして取り付けられており，頂部部材４３に固定された羽根状部材４２ａ，４２ｂのそれぞれの柄部４９ａ，４９ｂは蓋４８の開口に遊嵌している。

【００３０】ケース４４内の肉厚の円筒状の容器５０ａには本例の流体緩衝系の主要部を構成する粘性流体４５が漏れなき状態で充填されており，羽根状部材４２ａ，４２ｂの羽根部分は粘性流体４５中に浸されている。また，ケース４４の表面には一対の電極４６が設けられ，これらの電極４６は粘性流体４５と導通している。ここで使用される粘性流体４５は，後述するように電圧の変化に対応して粘性が変化するＥＲ（Electro Reological）流体であり，外部に設けた電源から一対の電極４６の間に印加した電圧を変化させると粘性流体４５の粘性が変化し，結果的に防振マウント１２ａの減衰定特性が変化する。この粘性流体の粘性は，防振マウント１２ａの外部に設けられた制御系１９により制御される。

【００３１】次に，本例の流体緩衝系を構成する粘性流体４５について説明する。前述の通り，粘性流体４５は粘性流体に印加される電圧の変化に対応して，その粘度が変化するＥＲ流体である。このＥＲ流体は，そのままの状態では，流動性をもつコロイド溶液であるが，数ｋＶ／mmの電界をかけると電界の強さに比例して流動性を失い，ＥＲ流体の種類によっては固体に近い状態まで変化する。更に，ＥＲ流体における粘性の変化の応答速度は例えば０．１ｓｅｃ程度であり，例えばステッパ型やステップ・アンド・スキャン方式の投影露光装置に容易に適用できる応答速度を有している。

【００３２】このＥＲ流体としては，シリコンオイル等の絶縁性の流体中に電気分極性の粒子を分散させた分散型のものと，最近では液晶を使用した液晶型のものがある。分散型のＥＲ流体は，価格的には安いが，分散させた粒子が溶液中から分離する欠点がある。それに対し，液晶型のＥＲ流体は，粒子が分離することがなく，その他分散型のＥＲ流体ではＥＲ効果が消滅するようなせん断速度の高い領域でもＥＲ効果が失われない等の利点があるが，価格的に高いという難点がある。以上のＥＲ流体として既に各種の流体が，旭化成，日本石油，日本触媒，日本メクトロン，ダウコーニング，東レ等の各メーカーから市販されている。

【００３３】粘性流体４５としては，以上のＥＲ流体の内から特に粘性係数の変化が大きく，応答性がよく，消費電力が小さく，粒子の分散性に優れ，作動温度が広く，そして価格的に安い製品を選択する。次に，本例の

ステージ装置の動作につき説明する。図3は、本例で使用される防振マウント12aの振動モデルを説明するための模式図を示し、この図3において、露光装置本体11と露光装置の設置面であるベースプレート13の間に配置されて、露光装置本体11を支持する防振マウント12aの振動特性は、図2のばね部材20のばね定数K及び振動減衰部材である粘性流体45の粘性抵抗係数に基づくダンピング係数Cにより決定される。

【0034】本例では、ばね部材20のばね定数Kは一定である。従って、粘性流体45のの粘性抵抗係数に基づくダンピング係数Cを変化させることにより防振マウント12aの振動特性を変化させる。本例では粘性流体45としてER流体を用いている。現在、粘性流体に対する印加電圧を制御することによって粘性流体45の粘性係数を10倍以上の比で変更しうるER流体は入手可能であり、このようなER流体を適用することによって低周波域にある固有振動数における共振倍率のピークの高さ、及び中高周波域における振動伝達率を制御することができる。

【0035】前述のように、露光装置の防振台として必要な（イ）床面からの振動伝達の低減及び（ロ）装置内部で発生する振動の速い減衰、の2つの機能は、同時刻に満足する必要がないものである。（イ）の機能が最大限に必要となるのは、レチクル1のパターンがウエハ4に焼付け露光される時間、及び各種の光学的アライメント動作の時間等である。また、（ロ）の機能が重要となるのは、ウエハステージ及びレチクルステージ2を高速に移動させる際のレチクルステージ2及びウエハステージの加減速時間である。

【0036】図8は、本例のステッパ型の投影露光装置における、ウエハステージの駆動及び露光のタイミングを説明するためのグラフを示し、横軸に時間t、縦軸にウエハステージの速度VWを示している。先ず、期間71においてウエハステージは加速を行い、期間72の間は等速運行を行い、期間73においてウエハステージは減速する。その直後の期間74において微少範囲の位置決めを行い、その終了後の静止している期間75が露光時間である。トータル時間76は、以上の期間71～75の和であって、この周期でウエハステージの駆動及び露光が繰り返されている。また、縦軸上の速度VWはウエハステージの最高駆動速度を示している。

【0037】そこで、例えば本例のステージ装置において、防振マウント12a、12bの振動減衰特性を2通りに変化させる設定にすれば、露光装置の機能から考えると、結果的に（イ）及び（ロ）の2つの機能を共に満足する防振台とすることができる。即ち、露光時間である期間75においてのみ剛性を「柔らかく」する。即ち、粘性流体45の粘性を小さくすればよい。これにより、装置外部からの振動伝達がほぼ遮断される。その他のステージの加速減速に関わる時間には剛性を「かたく」しておけば、加速減速によって発生する振動は十分に速く静定することができる。

【0038】ところで、これらの時間管理は露光装置全体を制御する図2の制御系19により行われるが、本例の防振マウント12a，12bの特性変更のために特別なセンサを必要としない。即ち、制御系19から露光装置の運転状況に応じて制御信号を発し、粘性流体45に対する印加電圧を制御すればよい。従って、本例のステージ装置によればアクティブ防振台に比べ非常に安いコストで且つアクティブ防振台が有する機能を達成することができる。

【0039】更に、露光装置におけるレチクルステージ2及びウエハステージ等のステージの駆動及び停止の組み合わせは、露光動作においてのみ適用されるわけではなく、各種の光学的なアライメント動作及びウエハ4及びレチクル1等の入れ替え時のハンドラとの受渡し等の動作においても適用される。それぞれの場合に応じて、ステージの駆動速度及び加速度といった制御パラメータは異なっているのが普通である。従って、防振マウント12a，12bに設定されるべき「剛性」は「柔らかい／かたい」の2段階だけでなく、各ケースに応じて数段階、でき得れば4～5段階の設定値の変更ができることが好ましい。本例の粘性流体45の粘性を変化させる方式では、その剛性を所定範囲内で連続的に変化できるため、これらの複数の設定値を制御系19により容易に設定することができる。

【0040】次に、本発明によるステージ装置の他の実施例について図4を参照して説明する。図4は、本例の防振マウント21aの振動モデルを説明するための模式図を示す。本例は図1の実施例における防振マウント12aに代えて、ダンピング係数C，が一定で、ばね定数を変化させることができる防振マウント21aを用いたもので、図4に示すように粘性流体45Aによる流体緩衝系と一体化されたばね部材20Aに加えてその近傍に一個又は複数のばね部材25を挿脱自在に設けている。この場合、ばね部材25は粘性流体45Aによる流体緩衝系に一体化されていても、いなくてもどちらでもよい。なお、本例のステージ装置においても、図1と同様に4個の防振マウントが設けられる。

【0041】図4において、一個又は複数のばね部材25の一端はベースプレート13に固定されているが、他端は露光装置本体11とは常時接触せず、その他端と露光装置本体11の相対する面26とを駆動装置27により接続及び解放するような制御が行われる。この接続、解放動作を行う駆動装置27としては、電磁力、真空吸着力、及び空気圧の利用、及びモータ等による機械動作等のさまざまな駆動系が使用できる。駆動装置27の接続及び解放の制御は制御系19により行われる。その他の構成は図1のステージ装置と同じである。

【0042】図4の振動モデルにより本例の防振マウン

トの動作を簡単に説明する。なお、防振マウント２１ａに複数のばね部材が設けられた場合、それらのばね部材のばね定数はそれぞれ異なったものであるが、ばね定数K_2で代表して説明する。即ち、ばね部材２５の数の組み合わせによる変化の数だけばね定数K_2が変化することができるものとする。なお、粘性流体４５Ａの動作は制御系１９により制御されておらず、粘性流体４５Ａの粘性抵抗係数は殆ど環境温度だけに支配されるものである。従って常温ではダンピング係数C_1は一定として考える。

【００４３】防振マウント２１ａは、減衰特性を有する粘性流体４５Ａによる減衰特性に加えてばね部材２０Ａのばね定数K_1とばね部材２５のばね定数K_2との組み合わせによるばね定数K_Tを変化させることで、図１の実施例に比較して更に多くの振動特性値を設定することができる。ばね部材２５の数を例えばｎとすると、ばね定数K_2の変化の数Ｐは、ｎ個からｉ個を取る組み合わせを${}_nC_i$として、最大で$(1+{}_nC_1+{}_nC_2+\cdots+{}_nC_n)$となる。

【００４４】例えば、ばね部材２５の数が３個であれば、ばね定数K_2の変化数は最大で８となる。ばね定数K_Tの変化は連続的ではないが、所定個数のばね部材２５を設けることにより、殆ど連続に近い形のばね定数K_Tを得ることもできる。従って、ばね部材２０Ａ及び複数のばね部材２５と粘性流体４５Ａとの組み合わせにより、ステージ装置に対する様々な振動特性の要求に対応することができる。

【００４５】なお、本例では防振マウント２１ａは、ばね部材２０Ａ、２５によるばね緩衝系と粘性流体４５Ａによる流体緩衝系との組み合わせにより構成されたが、流体緩衝系がなくてもよい。しかしながら、ばね緩衝系と流体緩衝系の両者を組合わせて適用したほうが、より効果的である。次に、本発明によるステージ装置の別の実施例について図５を参照して説明する。本例は、図４の例と同様に防振マウントのばね定数を変化させるもので、ばね定数がK_3のばね部材２０Ｂによるばね緩衝系とダンピング係数C_2の粘性流体４５Ｂによる流体緩衝系から構成される防振マウント２８ａの近傍にボイスコイルモータ（以下「ＶＣＭ」という）方式のアクチュエータ３１を用いた補助の防振マウント３０を設けている。なお、本例のステージ装置においても、図１の例と同様に４個の防振マウントが設けられる。

【００４６】図５は、本例の防振マウントの振動モデルを説明するための模式図を示し、図５に示すように防振マウント２８ａの近傍に下部がベースプレート１３に固定された補助の防振マウント３０が設置されている。防振マウント３０を構成するＶＣＭアクチュエータ３１は、露光装置本体１１に固定されたコイル部３１ａ及び防振マウント３０ａに固定されたマグネット部３１ｂ等から構成され、コイル部３１ａに流す電流に応じてベースプレート１３から露光装置本体１１に対する付勢力が変化するようになっている。

【００４７】露光装置本体１１の位置は、露光装置本体１１の底部に面して設けられ、露光装置本体１１の底部の張り出し部１１ａの位置（高さ）を検出する位置センサ３３Ａにより計測される。位置センサ３３Ａは、支持フレーム３８Ａを介してベースプレート１３に固定されており、位置センサ３３Ａとベースプレート１３との位置関係は一定している。位置センサ３３Ａの計測値は、位置ゲイン回路３９Ａに供給されており、補助の防振マウント３０のＶＣＭアクチュエータ３１は、位置センサ３３Ａの計測値のずれ量を０にする方向に所定のゲインで付勢力を発生するように位置ゲイン回路３９Ａにより制御される。そして、本例では制御系１９が位置ゲイン回路３９Ａにおける位置のゲインを変更することにより間接的にＶＣＭアクチュエータ３１のばね定数を変更する。また、位置センサ３３Ａとしては種々の測長センサが使用できるが、レーザ反射型センサ及び渦電流センサ等の使用がコスト的な面から好ましい。その他の構成は図１のステージ装置と同様である。

【００４８】次に、本発明によるステージ装置の更に別の実施例について図６を参照して説明する。本例は、防振マウントとしてモータ駆動で送りねじ方式のアクチュエータを用いたもので、本例では上述実施例のようなばね緩衝系及び流体緩衝系からなる防振マウントを設けていない。なお、本例のステージ装置においても、図１と同様に４個の防振マウントが設けられる。

【００４９】図６は、本例の防振マウントの振動モデルを説明するための模式図を示し、この図６において、下部がベースプレート１３に固定された防振マウント３２ａが設置されている。防振マウント３２ａの駆動機構を構成する電気式のアクチュエータ３４は、露光装置本体１１の対向する面２６Ａに突き当たるスピンドル３４ｃ、このスピンドル３４ｃのナット部に螺合するねじ部３４ａ及びこのねじ部３４ａを回転する駆動モータ３４ｂ等から構成されている。防振マウント３２ａの底部はベースプレート１３に固定され、露光装置本体１１からの振動を吸収する構成となっている。

【００５０】露光装置本体１１の位置は、図５のステージ装置と同様に、露光装置本体１１の底部の張り出し部１１ａの位置を検出する位置センサ３３Ａにより計測される。位置センサ３３Ａの計測値は位置ゲイン回路３９Ｂに供給されており、位置ゲイン回路３９Ｂは位置センサ３３Ａの計測値のずれ量を０にするようにアクチュエータ３４の露光装置本体１１に対する付勢力を所定の位置ゲインで制御する。本例でも制御系１９はその位置ゲイン回路３９Ｂにおける位置ゲインを調整して、アクチュエータ３４におけるばね定数を変化させる。その他の構成は図１のステージ装置と同じである。

【００５１】本例の送りねじと駆動モータとからなるア

クチュエータ34は、図5のVCMアクチュエータ31と異なり、荷重の大きな装置に対しても単独で適用できるものである。しかしながら、他のばね緩衝系又は流体緩衝系からなる防振マウントと併用してもよい。次に、図5のステージ装置の変形例について図7を参照して説明する。本例は、図5の補助の防振マウント30と露光装置本体11との間にロードセルを配したものである。

【0052】図7は、本例の防振マウントの振動モデルを説明するための模式図を示し、図7において、露光装置本体11の底面とVCMアクチュエータ31を有する防振マウント30の外筒の上面との間にロードセル35が配置されている。ロードセル35からの荷重の測定値は駆動回路39Cに供給され、駆動回路39Cには位置センサ33Aからの位置の測定結果も供給されている。駆動回路39Cはロードセル35で検出される荷重、即ち力を変位センサ33Aで検出されるずれ量（変位）で除した値であるばね定数を所定の値にするようにVCMアクチュエータ31の付勢力を制御する。また、制御系19は必要に応じてその駆動回路39Cにおけるばね定数の値を変更させる。その他の構成は図5のステージ装置と同様である。

【0053】図7の振動モデルにより本例の防振マウントの動作を簡単に説明する。本例の防振マウントは、減衰特性を有する粘性流体45Bによる減衰特性に加えてばね部材20Bのばね定数K_3と補助の防振マウント30を構成するVCMアクチュエータ31のばね定数K_4との組み合わせによるばね定数K_Tを変化させることで、種々の制振特性を設定することができる。

【0054】ロードセル35にかかる力を作用力Fとし、位置センサ33Aで測定される露光装置本体11の位置のずれ量を変位Δxとすると、作用力FをΔxで除した値（F／Δx）は、VCMアクチュエータ31をばね材料とみた場合には、通常のばね定数と等価である。従って、ばね定数K_4は（F／Δx）であり、ばね定数K_4を変えるには同一の変位Δxに対する作用力Fを変えればよい。そのため、制御系19によりコイル31aに流す電流を制御することによりVCMアクチュエータ31のばね定数K_4を変えることができる。

【0055】本例の方法によれば、VCMアクチュエータ31による補助の防振マウント30を設けているので、VCMアクチュエータ31を駆動回路39Cにより電気的に制御するだけで、ステージ装置全体のばね定数K_Tを幅広く変化させることができ、ステージ装置に対する様々な振動特性の要求に対応することができる。以上の実施例によるステージ装置によれば、露光装置本体11と露光装置の設置面となるベースプレート13との間にばね緩衝系及び流体緩衝系からなる防振マウントを設置して、露光装置のレチクルステージ2やウエハステージの移動に伴う振動や露光装置の設置面からの振動等の種々の異なる振動を緩衝し、露光装置の性能を向上させることができる。

【0056】なお、上述の実施例におけるばね部材として空気ばねを用いてもよい。また、流体緩衝系として例えば空圧シリンダ等の空気を利用した緩衝系を用いることもできる。なお、上記の実施例は本発明のステージ装置をステッパ型の投影露光装置に適用したものであるが、レチクルとウエハとを同期して走査するステップ・アンド・スキャン方式の露光装置に適用することもできる。

【0057】図9は、ステップ・アンド・スキャン方式の露光装置のウエハステージの駆動及び露光のタイミングを説明するためのグラフを示し、横軸に時間t、縦軸にウエハステージの速度VWを示している。図9に示すように、期間77においてウエハステージは加速を行い、その直後の期間78において所定の走査速度への収束を行い、走査速度が一定となる期間79において露光が行われる。期間79の間ウエハステージは走査速度VW_1で移動する。露光が終了すると、期間80においてウエハステージは減速する。その直後の期間81において次の露光ショットの走査開始位置への位置決めが行われる。トータル時間82は、以上の期間77～81の和であって、この周期でウエハステージの駆動及び露光が繰り返されている。

【0058】ステッパ型のステージ装置と同様に、露光時間である期間79においてのみ剛性を「柔らかく」すればよい。その他のステージの加速減速に関わる時間に剛性を「かたく」しておけば、加速減速によって発生する振動は十分に速く静定することができる。また、上述実施例では、ばね部材として圧縮コイルばねが使用されているが、その他に板ばねや鉄板等を使用してもよい。

【0059】このように本発明は上述実施例に限定されず、本発明の要旨を逸脱しない範囲で種々の構成を取り得る。

【0060】

【発明の効果】本発明の第1のステージ装置によれば、可動体の移動状態に応じて、振動減衰手段の振動特性を減衰特性可変手段により変化させて、ステージ装置の振動減衰特性を変えることができる。従って例えばステージ装置に対するステージ装置外部からの振動を伝達したくないような場合には、振動減衰手段の剛性を小さく設定し、一方、例えば可動体の移動に伴うような装置内部での振動を速く収束させたい場合には、振動減衰手段の剛性を高くすることにより対応することができる。

【0061】また、本発明の第2のステージ装置によれば、露光装置のステージ装置として露光時点及び基板ステージの移動時に必要な（イ）床面からの振動伝達の低減及び（ロ）装置内部で発生する振動の速い減衰、の2つの機能を共に安いコストで満足させることができる。更に、露光動作においてのみでなく、各種の光学的なアライメント動作及びマスク及び感光基板等の入れ替え時

のハンドラとの受渡し等の動作においても基板ステージの振動特性を考慮する必要がある。本発明の第2のステージ装置によれば、これらの複数の設定値を減衰特性可変手段により容易に設定することができる。

【0062】また、本発明の第1及び第2のステージ装置において、所定の1個又は複数個の振動減衰手段が、それぞれ所定の粘性流体中に配置された可動体を有し、減衰特性可変手段が粘性流体の粘性抵抗係数を変化させてダンピング係数を変化させる場合には、例えば粘性流体として電界の強さにより粘性抵抗係数が変化するＥＲ（Electro Reological）流体を使用した場合、外部に設けた電源から粘性流体に通電する電圧を減衰特性可変手段により制御するするだけで粘性流体の粘性抵抗係数が変化し、それに伴ってダンピング係数が変化し、結果的に基板ステージの移動状態に応じて振動減衰手段の振動減衰特性を制御することができる。更に、所定範囲で連続的に振動減衰特性を変化させることができる。

【0063】また、減衰特性可変手段が、減衰特性の可変対象となるその振動減衰手段と並列に設置面とベースとの間に一個又は複数個のばね部材を挿脱することによりばね定数を変化させる場合には、例えば、複数個のばね部材を設置面とベースとの間で挿脱すれば、きわめて簡素な構成で振動減衰特性を複数段階に切り換えることができる。

【0064】また、電気的なアクチュエータでばね定数を変化させる場合には、機構的に簡便である。更に、完全なアクティブ防振台のように変位センサ等の検出値に応じて複雑な制御を行うのではなく、単に位置フィードバックのゲインや力／変位の値を変えるだけの制御でよいため、制御回路はそれほど複雑化しない利点がある。

【図面の簡単な説明】

【図１】本発明によるステージ装置が適用された露光装置の一実施例を示す概略構成図である。

【図２】図１の防振マウント１２ａの内部構成を示す断面図である。

【図３】図１の防振マウント１２ａの振動モデルを示す模式図である。

【図４】本発明のステージ装置の他の実施例の振動モデルを示す模式図である。

【図５】本発明のステージ装置のもう１つの他の実施例の振動モデルを示す模式図である。

【図６】本発明のステージ装置の更にもう１つの他の実施例の振動モデルを示す模式図である。

【図７】図５のステージ装置の変形例の振動モデルを示す模式図である。

【図８】図１の露光装置のウエハステージの速度制御の状態を示す図である。

【図９】ステップ・アンド・スキャン方式の露光装置のウエハステージの速度制御の状態を示す図である。

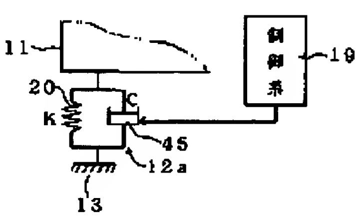
【図１０】従来のステージ装置が適用された露光装置の一例を示す概略構成図である。

【図１１】従来のステージ装置が適用された露光装置の他の例を示す概略構成図である。

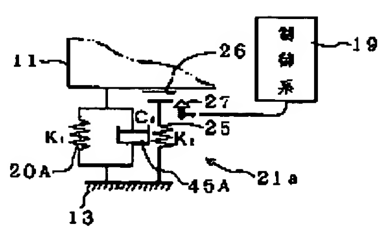
【符号の説明】

1　レチクル
2　レチクルステージ
3　投影光学系
4　ウエハ
6　Ｘステージ
7　Ｙステージ
8　ウエハベース
9　定盤
１１　露光装置本体
１２ａ，１２ｂ，２１ａ，２８ａ，３０，３２ａ　防振マウント
１３　ベースプレート
１９　制御系
２０，２０Ａ，２０Ｂ，２５　ばね部材
４５，４５Ａ，４５Ｂ　粘性流体
２７　駆動系
４２ａ，４２ｂ　羽根状部材
３１　ボイスコイルモータ（ＶＣＭ）式アクチュエータ
３３Ａ　位置センサ
３４　送りねじ式アクチュエータ
３９Ａ　位置ゲイン回路
３５　ロードセル

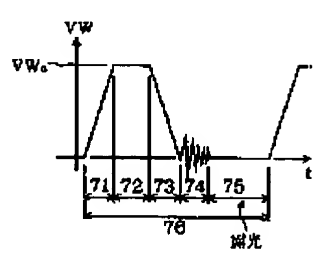
【図３】



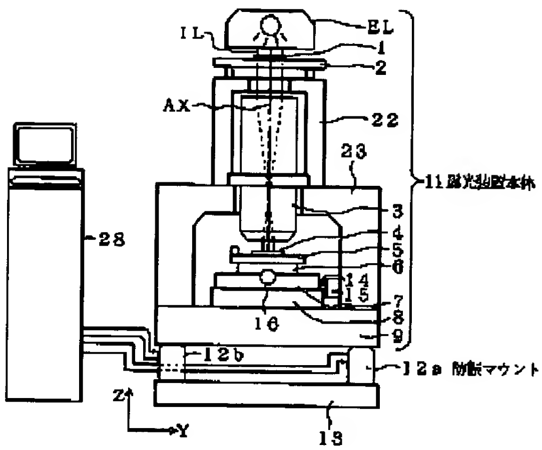
【図４】



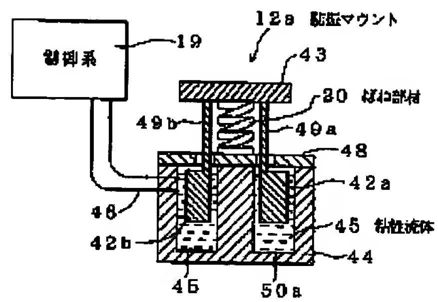
【図８】



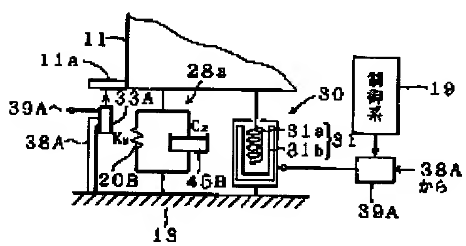
【図1】



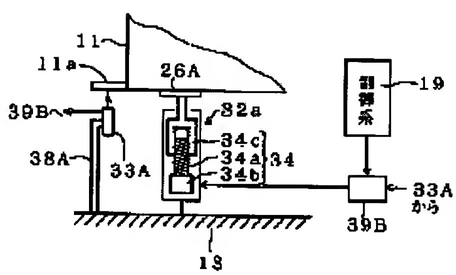
【図2】



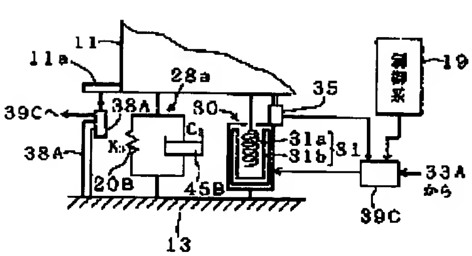
【図5】



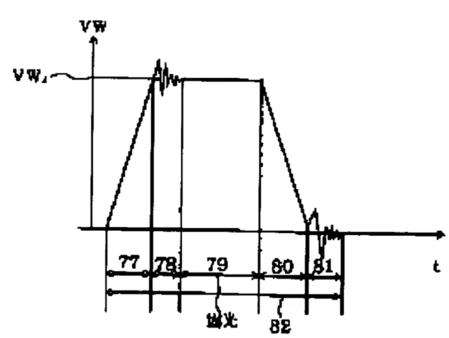
【図6】



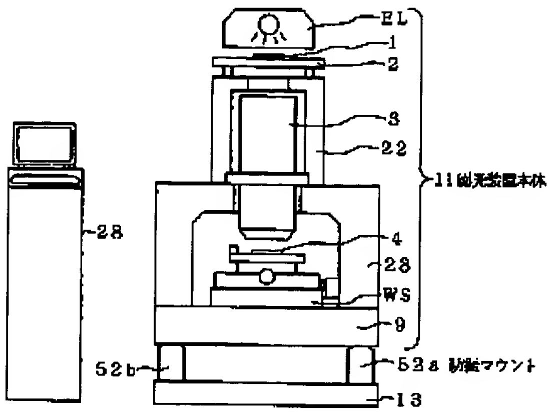
【図7】



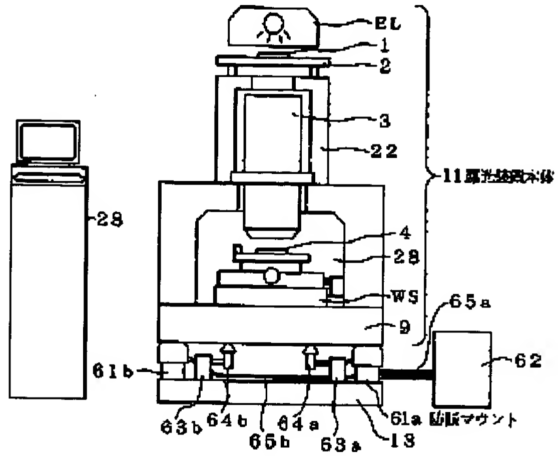
【図9】



【図１０】



【図１１】



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